

CONTRIBUTIONS TO THE PHOTOGRAPHIC STUDY
OF COLOUR, RESOLUTION AND TOTAL
MAGNITUDE OF ANAGALACTIC
OBJECTS

WITH SPECIAL REGARD TO OBJECTS PHOTOGRAPHED AT HELWAN

BY

BJÖRN SVENONIUS

PUBLISHED BY THE OBSERVATORY
LUND, SWEDEN

1938

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WITH SPECIAL REGARD TO OBJECTS PHOTOGRAPHED AT HELWAN

ACADEMICAL DISSERTATION

BY

BJÖRN SVENONIUS

FIL. LIC., ÖG.

BY DUE PERMISSION OF THE PHILOSOPHICAL FACULTY OF THE
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TO

KNUT LUNDMARK
LUND

ARVID ODENCRANTS
STOCKHOLM

AND

MOHAMMED REDA MADWAR
HELWAN

THIS WORK IS DEDICATED

TABLE OF CONTENTS.

	Page
INTRODUCTION	9
Part 1. CONTRIBUTIONS TO THE PHOTOGRAPHIC METHOD	
Chapter I. The atmosphere	12
A. Atmospherical dispersion and absorption	12
B. Visual determination of the extinction coefficient	13
C. Photographic determination of the extinction coefficient	22
Chapter II. The 30-inch Reynolds reflector	28
A. The instrumental halo with special regard to the Reynolds reflector	28
B. Changes of focal length of the Reynolds reflector	32
Chapter III. The photographic plate	42
A. The reflection halo	42
B. Sensibility and diffusion halo	46
Part 2. CONTRIBUTIONS TO COLOUR, RESOLUTION AND TOTAL MAGNITUDE OF ANAGALACTIC OBJECTS	
Chapter IV. Influence of spectral gradation on the determination of colour of anagalactic objects	70
Chapter V. A photographic classification of the resolution of anagalactic objects	76
Chapter VI. Relations of the photographic resolution to some other apparent properties of the objects	81
Chapter VII. A comparison of original plates and diapositives regarding dimensions, total magnitude and resolution of anagalactic objects	89
Chapter VIII. The resolution of anagalactic objects photographed at Helwan, related to the resolution of objects on diapositives of photographs originating from the 60- and 100-inch telescopes of Mt Wilson Observatory and the Crossley reflector of Lick Observatory . .	93
Chapter IX. Photometrical studies of structures of anagalactic objects	108
A. Structures obtained by measurements with microphotometers	108
B. Structures obtained by measurements based on counts of developed silver grains	111
Chapter X. Some systematical errors of personal character and the mean error entering into the estimation of total magnitude of anagalactic objects, when compared with stars or mutually compared	116
A. On the error in comparing an anagalactic object with a single star of an intensity different from that of the object	117

	B. The surface error in comparing an object with one or several objects (stars or anagalactic objects) of the same intensity as the object to be estimated	120
	C. On the influence of the geometrical form in comparing anagalactic objects with stars or anagalactic objects with each other	125
	D. The accuracy in the estimation of photographic densities	127
Appendix	I. Visual observations for a computation of extinction coefficients for the Helwan Observatory	131
Appendix	II. Catalogue of focus-tests of the 30-inch Reynolds reflector	137
Appendix	III. Catalogue of anagalactic objects photographed at Helwan, for which resolution, dimensions and total magnitude have been determined	152
PLATES		161

INTRODUCTION.

The present investigation forms part of a series of papers on anagalactic objects planned by Professor KNUT LUNDMARK and now being worked out at the Lund Observatory.

According to the original plan, in connection with a visit to the Helwan Observatory in Egypt, I was to take up for discussion different problems on the resolution of anagalactic objects in the Helwan zone ($\delta = 0^\circ$ to -40°). My stay at the Helwan Observatory took place in 1934—35 and lasted for one year. Thanks to the great courtesy of Dr M. R. MADWAR, Director of the Helwan Observatory, during that time I was able to make frequent use of the 30-inch Reynolds reflector. The number of plates taken by me during my stay there amounted to about 250, most of them exposed on nebulae, although a great many of them were replicas of already photographed objects and intended for my studies of the photographic method.

My interest in the method of photographing anagalactic objects with the best possible appearance of them as result has made me wish also to include something about the photographic method here. This has been done, and the present paper may naturally be divided into two parts: the first dealing with the photographic method, the second with colour, resolution and total magnitude of the objects.

In the first part will be found an investigation of the factors which have influence on colour, resolution and total magnitude of the objects, viz. the atmosphere, the instrument and the photographic plate.

With regard to the atmosphere, where the amount of halo is directly dependent on the extinction, that is the loss of magnitude of the object in the moment of observation, I have devoted special interest to a method of rapidly determining the actual extinction coefficient. Mean values of the extinction coefficient, which are given by different observers, are in my opinion of secondary use. It was found that the simple extinction formula $m - m_0 = f \sec z$ was quite valid up to zenith distances of 88° . Thanks to the free horizon and the sometimes very clear nights at Helwan, it was possible to make observations at the astronomical horizon or very little above it. Purely visual estimates were found very quickly to give a value of sufficient accuracy, and this method was considered more convenient than an attempted photographic method.

By the use of the spectral sensitiveness of photographic plates examined in this paper and the spectral transmission coefficients given by FOWLE, the ratio between photographic and visual extinction coefficients has been investigated. Owing to the spectral variation of gradation (γ) of a plate it is shown that the ratio can vary within wide limits.

With the instrument, my attention was especially directed to the variation of its apparent focal length with temperature. An earlier, unpublished attempt made at Helwan on the same subject, to which my attention was drawn by Dr MADWAR, had given no decisive result. I found that the change of the focal length has a

minimum in the temperature interval lying just around the yearly mean temperature of Helwan. I do not know whether this fact is accidental, or due to the constructors of the telescope.

The means given by photography, the photographic plate, has been investigated with regard to sensitiveness, gradation and resolving power, the most important qualities affecting the result in nebular photography. The spectral sensitiveness and gradation were determined by a quartz spectrograph and with a calibrated lamp as source of light. The variation of gamma, which is mainly influenced by development conditions, is discussed. From the spectral properties the corresponding total properties were determined for a *G0*-spectrum (approximately that of anagalactic objects) and with regard to influence of the atmosphere and the reflector. The photographic resolving power, defined by a number of qualities of the plate and its treatment, is also given for together more than twenty different kinds of plates, all made frequent use of in astronomical photography. Although it is very difficult to allow for the age of a plate and differences in the same manufacture of plates, it is hoped that this collection of data will have some interest.

The second part of the present paper deals with the objects themselves, here usually called anagalactic objects according to the nomenclature by LUNDMARK.

The influence of spectral variation of gamma of a plate is shown to be of a serious nature in determining the colour of objects widely differing with regard to photographic density, as the galaxies do. Colour differences found for five nebulae were regarded as caused at least partly by differences in spectral gradation.

A scale of photographic resolution (R) for anagalactic objects is introduced, running from $0^{\cdot}0$ to $10^{\cdot}0$, in which the estimates are carried out in tenths. The accuracy of a single estimate was found to be as good as $0^{\cdot}4$. The number according to the scale was put in relation to the apparent dimensions and the apparent total magnitude, the latter quantity being determined from star counts according to LUNDMARK's method. By using diapositives from the Mt Wilson Observatory and the Lick Observatory, kindly put at my disposal by Prof. LUNDMARK, I also had opportunity to make a comparison of the resolution as obtained with some different instruments.

A photometry with regard to recording structures was made for some selected objects, in order to compare different methods. A method based on counts of developed silver grains was worked out, and it proved to give results very accordant with microphotometrical methods.

Finally I have investigated some errors entering into the estimation of total magnitude of anagalactic objects according to the mentioned method. My considerations take regard to the errors of personal character entering into a comparison of one, with regard to magnitude, unknown galaxy with one or several known stars or galaxies. The error has been considered as composed of a surface error and an intensity (density) error. After determining these separately by the help of accurately measured surfaces and densities respectively, the errors have been summed up and the results compared with actual observations of galaxies.

It is an agreeable duty and a great pleasure to me to express my sincere thanks to Professor KNUT LUNDMARK, who drew my attention to the subjects of the present paper. He has also contributed much to the carrying out of the investigation, and facilitated my work. Parallel with me, he made estimates in the scale of resolution. From his wide experience of nebulae I feel sure that the scale may be considered as suitable in its present state.

To Dr M. R. MADWAR, Bey, Director of the Helwan Observatory, who introduced me to nebular photography and who gave me much help during my stay at the Helwan Observatory, I wish to express my sincere thanks.

I am also very thankful that he let me make unrestricted use of the excellent collection of nebular plates belonging to the Helwan Observatory. To Dr A. H. SAMAHA, Helwan, who during a visit to Lund in Aug. to Oct. 1937 has taken active part by doing a number of measurements, I wish to express my gratitude.

The determination of the qualities of the photographic plates was planned and partly carried out in the Photographical Laboratory of the General Staff (Generalstabén), Stockholm, during a two months' stay there in 1936. To Professor ARVID ODENCRANTS, the Director of this Laboratory, it is a pleasant duty to tender my esteem for his valuable guidance and lasting interest in my work. I am also very thankful that he let me publish his excellent formula for a metol-adurol developer, which for the purpose of obtaining good resolving power of the investigated plates was shown to be unsurpassed.

The photography of spectra on the plates was performed in the Physical Institute, Lund. To Professor JOHN KOCH, the Director, who was kind enough to provide apparatus needed for my work, I wish to express my appreciation. In the exposing of the plates in the spectrograph, as well as in their photometry, I had much help from Dr NILS RYDE, who also kindly put a calibrated lamp at my disposal, for all of which I thank him. I am also very thankful to L. STIGMARK, who has given me long and energetic assistance at the spectrograph and the photometer.

The microphotometry of the objects was carried out during a stay in 1936 at the Stockholm Observatory, Saltsjöbaden, where Professor BERTIL LINDBLAD, the Director, kindly allowed me to work with the photometers, for which I thank him. To Dr GUNNAR MALMQUIST, Saltsjöbaden, who has taken active interest in Chap. I and IX A of my work and given me friendly and valuable criticism, I wish to express my grateful thanks.

To Professor WALTER GYLLENBERG, to Fil. Mag. C. G. DANVER and to other members of the staff of the Observatory of Lund I wish to express my thanks for valuable discussions and friendly criticisms.

I must thank Dr W. NORLIND, librarian at the University Library of Lund, who during many years with understanding and interest for my work has satisfied my need of certain books. He has also checked the quotations in this paper.

To J. AMUNDSSON, F. BERGLUND, B. EKENBERG, N. HANSSON, I. HEDBERG, G. LILJEQUIST and S. SUNNER, who have been kind enough to contribute with estimates discussed here in connection with systematical errors of a personal character, I express my great thanks. G. LILJEQUIST and N. HANSSON have, besides, during some months taken part in the computation work. For their assistance, and for discussions touched upon in connection with the subjects in question, my grateful thanks.

Most of the extensive computations, the drawing of the diagrams etc. have however been done by Miss M. PERSSON and Miss I. LUND. For their good help I express my best thanks.

In conclusion I wish to mention with much gratitude that my work was helped by pecuniary support from Bokelundska stipendiefonden, Lund, for my visit to Helwan; from Kungl. Fysiografiska Sällskapet, Lund, for statistical work on the resolution classification and for reproduction of original plates; and from Längmanska Kulturfonden for the plate material and the laboratory experiments on the properties of the photographic plates. Also other funds of the Lund and Uppsala Universities have been awarded me for my work, for all of which my thankfulness is great.

PART 1. CONTRIBUTIONS TO THE PHOTOGRAPHIC METHOD.

CHAPTER I.

THE ATMOSPHERE.

A. ATMOSPHERICAL DISPERSION AND ABSORPTION.

Every ray of light from a star or another celestial object reaching an observer has on its way through the atmosphere of the earth diminished in intensity by absorption and dispersion. But at the same time as there is a diminishing of intensity (extinction) in the light, there is also an expansion of the rays of light, two quantities that are closely connected with each other. Both are extremely important for every kind of astronomical photography, but perhaps most important for the study of the minute structural details of anagalactic objects, and especially so for a possible separation of individual stars or groups of stars in these objects. The designation »atmospherical halo» means the expansion that the rays of light undergo in the atmosphere, a quantity that especially varies with the state of the lower strata of the atmosphere. For obtaining the best possible resolution, the atmospherical halo in the moment of exposure ought to be the smallest possible, and hence it is clear that the observer has great use of knowing the actual state of the atmosphere. Instead of direct observation of the atmospherical halo, it is preferable to determine the extinction coefficient, with which it is directly related, and which is easy to determine both rapidly and accurately. At the same time, the extinction coefficient of course gives differences in magnitude for different altitudes or at different epochs.

Firstly, some words as to the atmosphere. The extinction of light has one rather constant component, caused by the pure, dry and continuous air layer, and another more variable component, caused by particles suspended in the air, e. g. water vapour, smoke and dust. The latter component includes what is usually called the haze effect, although that word is sometimes used for expressing every diminishing of light in the atmosphere.¹ A haze effect will also arise from discontinuous variations of temperature and pressure of the air.

The dispersion of light against the particles suspended in the atmosphere is caused by reflection, refraction and diffraction. The relative percentage of the light thus dispersed is dependent on the frequency distribution of the real sizes and the optical properties of the molecules and particles, and also on the quality of the light. For small particles diffraction predominates, with larger particles refraction and reflection.

¹ Kodak Monographs No 4 (1923).

As was said, not only is the brightness, for example of a star, diminished, but, especially at lower altitudes, the images will be more diffuse and extended, and sudden variations of light also enter, all making observations of the stars more difficult. This widening of the images is the atmospherical halo, which in visual observations as well as in photography will diminish the resolving power of the instrument. Thus e. g. double stars or the components of star clusters or resolved galaxies having relative distances below a certain limit will not appear separated for a certain definite extinction. The limit of resolving power according to atmospherical dispersion and unsteadiness in the atmosphere lies at about $0''.9$.¹

The difference in magnitude of a zenith star as seen through the air and as seen free from the effect of the air defines the extinction coefficient (the extinction factor). As is well-known this coefficient forms the basis for determining the extinction at any zenith distance, this latter being a function of the extinction coefficient and the zenith distance. Since the extinction coefficient varies to a considerable degree from night to night or even from hour to hour, the momentaneous or at least the mean value of the extinction must necessarily be observed for a successful photometry, and also for other observational problems.

In fact, it does not matter if we determine the extinction coefficient visually or photographically. For it is always possible to convert the values obtained by one method into the corresponding values of the other method. I have made use of both methods, and in the following two parts of this chapter something will be said about this.

B. VISUAL DETERMINATION OF THE EXTINCTION COEFFICIENT.

The method of observation was the following. A bright star at a relatively low altitude was purely visually equalled in brightness with a suitable fainter star at higher altitude. I was told by Prof. LUNDMARK that this arrangement has been used earlier by E. HERTZSPRUNG for the same purpose, although nothing has appeared in print about it. The same method was already made use of by L. SEIDEL ² in 1848, the first one to determine the extinction coefficient by observations, although with instrumental means.

In my arrangement a rising or setting bright star was examined by the naked eye and equalled in magnitude with as many stars as possible, provided that their brightness and position were suitable. In this way fairly extensive series of observations of the same star could often be obtained. Such observations of stars at low altitudes are very suitable at the Helwan Observatory since the apparent horizon there only shows small deviations from the astronomical horizon. The limits found by measurements with a theodolite were $+2'.1$ and $-0'.6$. (Tab. 1.)

Table 1. *The true horizon of Helwan as measured from the Meteorological Tower of the Observatory.*

Azimuth	0°	20°	40°	60°	80°	100°	120°	140°	160°	180°	200°	220°	240°	260°	280°	300°	320°	340°
Horizon	1'.2	2'.0	1'.4	1'.3	1'.1	0'.7	0'.6	0'.1	0'.0	—0'.4	—0'.6	—0'.4	—0'.2	—0'.2	—0'.2	—0'.2	—0'.4	0'.1

¹ DAVIDSON CHR. R. & BERNHEIMER W. E., Handbuch der wiss und angew Photogr, Bd 6:1 (1931) p. 233.

² Abhandlungen der K Bayer Akad d Wiss II Classe, Bd 6 (1852) p. 541.

With few exceptions, only bright stars are included in the observations, and moreover only stars which show no variability in magnitude. Polaris was nevertheless included, but no corrections were applied for its amplitude in light variation ($0^m.06$).

The magnitudes, when brought into computation, were taken from E. ZINNER's¹ catalogue of bright stars.

From the local sidereal time at the moment of observation the stars' declinations and hour angles were converted into altitudes and azimuths by means of the nomogram of L. BECKER.² As a check the chart of M. R. MADWAR³ was used, valid for the latitude of Helwan and giving an accuracy of about half a degree. For the former chart the error in one estimate was found to be only a few minutes of arc, and hence this graphical method, which in rapidity is much superior to computations, is sufficient even for low altitudes. With the extinction coefficient 0.20 a difference in altitude of $5'$ makes at 10° about $0^m.01$ and at 2° about $0^m.10$ in observed magnitude difference.

Appendix I contains 350 observations, together with data necessary for the discussion of the observations or data obtained as results.

The method of computation was a successive approximation, already used in principle by SEIDEL.⁴ For the stars at the higher altitude, designated Star II in Appendix I, it was assumed that the extinction formula of W. M. SMART⁵

$$m - m_0 = f \sec z - g \sec^3 z$$

was valid, being an extension of the well-known simple formula

$$m - m_0 = f \sec z$$

In fact, the formula of SMART fits the observations of E. S. KING⁶ and other observers very well, and also the present ones up to $z = 78^\circ$. The value of the coefficient g was found by SMART for photoelectric observations to be $0.003f$ as an average value.

The term added in the formula by SMART has rather little importance for the altitudes mentioned here, partly on account of the fact that f for visual observations is relatively small. With $f = 0.15$ and $z = 75^\circ$ we have $g \sec^3 z = 0^m.026$. For greater zenith distances the term however increases rapidly and then with this g his formula is not valid.

Now at first Star II was given a value corresponding to an arbitrarily chosen f , for example $f = 0.15$. By addition of the extinction value of Star II to the difference in magnitude from ZINNER's catalogue between the two stars compared, the extinction for Star I is found. From all values thus obtained for the observation night, forming together an extinction curve, it was seen whether the arbitrarily chosen coefficient was suitable. If not, it was evident in which direction a correction should be applied. After a few successive approximations the extinction curves for Stars I were considered as definite and their equations could be investigated more thoroughly. It was found that some nights presented so nearly the same extinction coefficients that the observations for these nights could be treated together. The nights numbered in order were taken together in this way: 8 + 10, 3 + 9, 7, 4, 1 + 2 + 5 and 6, mentioned here in order of increasing extinction coefficient.

¹ Bamberg Veröff 2 (1926).

² Chart belonging to MN 91 (1931) p. 226.

³ Chart belonging to Helwan Bull 36 (1933).

⁴ L. c.

⁵ MN 94 (1934) p. 115.

⁶ Harvard Ann 81 (1923) p. 204.

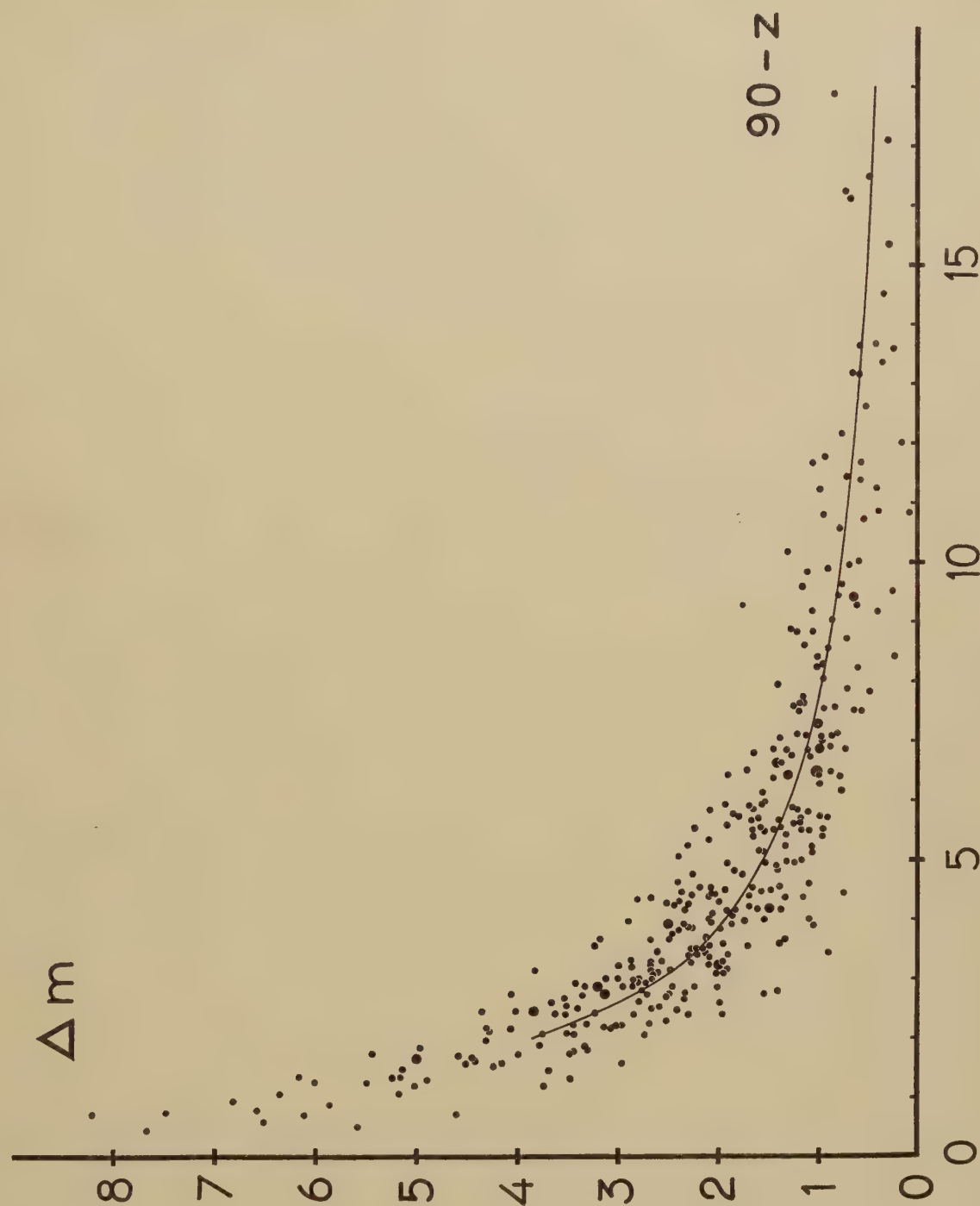


Fig. 1. An extinction curve constructed from comparisons of stars; observations by the naked eye made at Helwan. The curve drawn to $z = 88^\circ$ is the extinction curve from the formula $\Delta m = 0.135 \sec z$.

So far, through every group of points a curve was drawn in a purely graphical way. From these curves the amount of extinction was read off between the altitudes 3° and 11° , the limits included. All values read off were related to that curve which from the number of points ($n=85$) and their mutual distribution was considered to be one of the safest ($1+2+5$). The result of this manipulation appears in Table 2.

Table 2. *Ratio of extinction for different nights of observation, either single nights or several nights together.*

Altitude	Ratio of extinction for different nights of observation				
	$\frac{1+2+5}{8+10}$	$\frac{1+2+5}{3+9}$	$\frac{1+2+5}{7}$	$\frac{1+2+5}{4}$	$\frac{1+2+5}{6}$
3°	1.79	1.35	1.52	1.13	0.84
4	1.64	1.32	1.42	1.02	0.87
5	1.47	1.32	1.30	1.00	0.87
6	1.36	1.34	1.25	0.97	0.87
7	1.33	1.37	1.20	0.96	0.86
8	1.31	1.35	1.22	0.93	0.84
9	1.27	1.33	1.20	0.89	0.83
10	1.28	1.30	1.25	0.90	0.86
11	1.30	1.24	1.24	0.84	0.83
Mean:	1.41	1.32	1.29	0.96	0.85

The ratio between corresponding extinctions of two curves is not much varying, and it is to be supposed that the decrease for some of the curves only depends on erroneous drawing. With sufficient accuracy we conclude that down to 3° above the horizon the same extinction formula must be valid for different nights. If we distinguish between the least value of the extinction and the additional haze effect, the result also shows that the haze follows the same extinction formula as the pure air.

As we now know that one extinction curve may be obtained from another only by multiplications by a constant all over the curve, from the constants found above it is easy to reduce all the groups of points to a single group. In this way the point group which is seen in Fig. 1 is obtained.

This point group now is made use of for a discussion of the extinction formula valid for low altitudes. As mentioned before, the SMART formula fits observations up to 78° zenith distance, but then, owing to the second term, the theoretical curve runs below that observed.

The approximate differences amount to

$$\begin{array}{ll}
 z = 80^\circ & \Delta m \sim 0^m.05 \\
 82 & 0.20 \\
 85 & 0.70.
 \end{array}$$

A beautiful coincidence between formula and observations is however obtained by means of the simple formula

$$m - m_0 = f \sec z$$

The curve corresponding to this formula is drawn in Fig. 1 for $f = 0.135$ and up to $z = 88^\circ$, where the agreement is still close. The zenith distance 88° however signifies the limit of the validity of this formula. For 1° nearer the horizon the formula gives an extinction of about 8^m , whereas the observed extinction amounts to about $5^m.5$.

To this must be added that the SMART equation is theoretically founded, and a second term exists, although for visual observations its value is less than the above-mentioned $0.003f$. The theoretical basis is the curvature of the atmosphere, which sets in at lower altitudes in the formula. An approximate value of g for visual observations seems to be only $0.0001f$.

From the present observations it is easy to find not only the error of f , but also how many observations are necessary to get f determined with a certain accuracy.

It was found to be valid

$$m - m_0 = f \sec z$$

Thus for the two stars compared we have

$$m_1 - m_{01} = f \sec z_1$$

$$m_2 - m_{02} = f \sec z_2$$

After subtraction we get

$$\Delta m = f (\sec z_1 - \sec z_2)$$

A number of n observations then gives for the error of f , called δf ,

$$\delta f = \frac{1}{\sqrt{n}} \cdot \left(\frac{\overline{\delta \Delta m}}{\sec z_1 - \sec z_2} \right)$$

Here $\delta \Delta m$ designates the average error in one single observation of Δm , and the line above the brackets indicates that the mean value has to be taken of the expression below it. For an approximate solution there can be substituted for z_1 and z_2 the means of the values of these quantities entering into the observations made here.

$$\begin{array}{ll} z_1 = 84^\circ & \text{(or more exactly) } z_1 = 84^\circ 43' \\ z_2 = 63^\circ & z_2 = 62^\circ 26' \end{array}$$

which gives for $\sec z_1 - \sec z_2 \sim 7.5$.

From the last column in Appendix I it is found that the mean value of $\delta \Delta m$ amounts to about $0^m.30$. Thus we have

$$\delta f = \frac{0.04}{\sqrt{n}}$$

For $n = 15$ this gives $\delta f = 0.01$, which is of more than sufficient accuracy for practical purposes. A greater number of observations is of no use, since the systematical errors are difficult to account for and might sometimes be appreciable.

If a rapid determination of the extinction coefficient is wanted, the method with comparisons of stars near the horizon is very convenient. Without difficulty there can be made one observation every other minute, and thus for 15 observations only half an hour is needed. Photographic or photometric methods scarcely go below this time.

From the different nights when extinction coefficients were determined at Helwan it was found that f ranged between 0.12 and 0.20. As a mean value for good nights f may be put equal to 0.15. As said, this mean value has in fact only secondary importance, because the actual extinction has to be known for accurate photometrical purposes.

If we compare the present extinction curve with G. MÜLLER'S¹ well-known extinction table for Postdam, we find that the extinction for Helwan grows for the last 4 or 5 degrees above the horizon. This has its explanation, however, from the fact that below 5° above the horizon MÜLLER'S² measurements were carried out on exceptionally clear days, and the lowest portion of his extinction curve is different from the rest.

Since the extinction sometimes changes very rapidly, and since the same extinction formula is always valid, the assumption is not far off that, when such rapid changes in the atmosphere take place, it is not the distribution but the size or constitution of the particles in the atmosphere that undergo great changes.

Additional notes concerning the extinction coefficients. In the computation of extinction coefficients mentioned no consideration was taken of such factors as difference in azimuth, or the colour, or the mutual position of the stars observed. These factors, which are known usually to have influence, will be considered here with the help of the deviations of the individual observations from their respective curves, which uncorrected were on the average $0^m.29$.

Before entering on these factors I want, however, to discuss some observations which show very considerable deviations. As bad observations I consider the following seven in Appendix I: Nos. 121, 123, 163, 194, 200, 212 and 312. No. 123 was considered as uncertain, since the stars in the moment of observation were very faint. Some of the observations were on stars situated very near the horizon. The others may be affected by such a source of error as small undetected clouds, but are scarcely due to misinterpretation of one of the stars.

The following seven observations: Nos. 46, 208, 211, 220, 344, 346 and 349 have very considerable deviations, which are probably not wholly due to the observer. Thus No. 46 forms part of a series on Arcturus which is continuous in respect of the deviations, running to still higher negative values. Nos. 208, 211 and 220 (Δm about $-1^m.0$) are all on α Eridani, and 344, 346 and 349 (Δm about $+1^m.00$) all on α Carinæ. For α Carinæ (Canopus), of which the value of the magnitude ($-0^m.67$ in ZINNER'S catalogue) is discussed by several observers, it might be that the magnitude of the star is erroneous. My observations speak for the star by $-0^m.67$ being overestimated in brightness. Local disturbances in the extinction are also a possible source of error for these observations.

¹ Die Photometrie der Gestirne (1897) p. 515.

² L. c., p. 132.

If the fourteen observations discussed here are omitted, the average deviation of the remaining 336 differences amounts to $+0^m.26$. The fourteen stars are excluded from the following discussion.

From the individual deviations in Appendix I it is evident that there exists a higher absorption of light in certain azimuths. The haze was often seen to be thick over the Nile, that is over the western horizon. The eastern horizon was often extremely clear; see for example the observations of Sept. 17th 1934. The observations, which were carried out from the Meteorological Tower of the Helwan Observatory (height above sea-level about 130 *m*), were also disturbed in some directions by the lights of the town of Helwan, about one mile distant, and of a few more distant villages. The azimuths between which the horizon was illuminated were $0^\circ - 60^\circ$ and $110^\circ - 180^\circ$, that is, nearly all the western horizon was somewhat disturbed. Such places have been avoided in general. The illuminated horizon acts in the same direction as a greater absorption.

Corrections for azimuth were introduced for all the western horizon for altitudes less than 12° . The observations in question, 39 in number: Nos. 21, 37—40, 42—45, 47—49, 59, 61—64, 66, 74, 76, 77, 79, 89—95, 105, 119, 122, 124, 126, 150, 171, 223, 230 and 232, show a systematical deviation of $+0^m.21 \pm 0^m.04$.

If the deviations are put against altitude, a slight, approximately linear increase towards the horizon appears. The following correction (Δm) to the altitude (a) was introduced: $\Delta m = +0^m.25 - 0.015 a$.

With this correction the average deviation of the 336 observations diminishes to $0^m.25$.

For the day Sept. 17th 1934 a correction could be applied in the opposite direction for azimuths $260^\circ - 350^\circ$. This was, however, not done, nor was corrected for the slightly new position of the extinction curves in the point groups, where observations were omitted or corrected for azimuthal influence. For a clear picture of the distribution of the deviations into different azimuths, I had good help from dotting the observations on a map containing lines directed into different azimuths and a system of concentric circles.

An effect acting in a similar way as absorption enters if the stars or one of them are observed in the Zodiacal Light or the Milky Way. Recently B. FESSENKOFF¹ has investigated in detail the differences in brightness between these celestial light-structures and the common night sky.

The spectral class (colour) of the stars can play a part in two respects, in a personal colour equation and in a selective absorption in the atmosphere. The influence of spectral class is by some observers found to be rather great.

From together 100 magnitude estimations made at high altitudes, I found a personal colour equation as follows:

$$\begin{array}{l} \text{Difference } K \text{ and } M \text{ to } A = -0^m.07 \pm 0^m.04 \\ \quad \quad \quad \gg \quad F \quad \gg \quad G \quad \gg \quad A = -0.04 \pm 0.04 \end{array}$$

These values show that I estimate reddish stars a little too bright as compared with white stars. The difference is, however, not appreciable, and is not too certain, as the number of observations is modest and the mean error in a single estimate was large (about $0^m.20$). Thus it was not considered worth while to correct for these small amounts.

¹ Sternberg Publ 10: 2 (1937).

For the selective absorption SMART¹ declares that if for example $f = 0.35$ for $G0$ stars, this corresponds to about 0.39 for $B5$ stars. If we suppose the proportionality to be valid for visual observations, this would for $f = 0.12$ correspond to a difference of 0^m013 for the same two spectral types. From $\delta\Delta m = \delta f \sec z$ this gives for $z = 84^\circ$

$$\delta\Delta m = 0^m13$$

which is probably on the border of detection in the observations. If we consider that the lower star is more affected by a selective absorption, this effect would possibly appear if we group the deviations according to the spectral class of Star I. The results are found as follows: — (Table 3.)

Table 3.

Spectral class	<i>B</i>	<i>A</i>	<i>F</i>	<i>G</i>	<i>K</i>	<i>M</i>
Number of observations	95	84	45	24	81	7
Average deviation	$-0^m05 \pm .03$	$+0^m06 \pm .04$	$-0^m08 \pm .05$	$-0^m03 \pm .05$	$-0^m01 \pm .03$	$-0^m08 \pm .10$

We see that this manipulation gives no decided effect. The slight overweight of negative values (in mean 0^m01) is due to the previously mentioned correction for azimuth which was not counterbalanced.

The possible error of position was tested by grouping the differences in the catalogue in the following way: —

Three groups were formed:

- 1) Star II more than 5° to the *right* of Star I,
- 2) Star II more than 5° to the *left* of Star I, and
- 3) Star II within these limits.

The results of this manipulation are found in Table 4.

Table 4.

Relative position of Star I and II	Number of observations	Average deviation
Star II more than 5° to the right of Star I	128	$+0^m00 \pm 0^m03$
Star II more than 5° to the left of Star I	102	-0.02 ± 0.03
Star II less than 5° different in azimuth from Star I	106	-0.04 ± 0.03

From this we see that for the present writer practically no effect of position is to be found. A considerable error of position ($\sim 0^m3$) in comparing star magnitudes was found by G. ROUGIER, whereas other observers showed much smaller errors.²

¹ MN 94 (1931) p. 122.

² LUNDMARK in Handbuch der Astrophysik, Bd 5:1 (1932) p. 292.

A number of other systematical and accidental errors will arise, affecting the accuracy in the comparison of two stars.

Firstly, the method may be supposed to give results independent of each other only if the magnitudes of the stars are wholly unknown to the observer in the moment of observation. This factor is certainly of little importance in the present material, since appreciable differences from its zenithal magnitude exist for the lower star. For bright, high stars compared this source of error might however be serious.

The variability in the extinction, as said, affects the results, and further does so the extension of the stellar images. The errors in the time determinations and in the graphic method of computing the altitudes will also give rise to some effect. The latter error is avoidable, if it is wanted to spend time on accurate computations.

Another effect enters from the varying distance between the stars compared. A great distance makes the observations more difficult. The best observations will be made if the stars are so situated that they can be emphasized by the eye at the same time. To make this source of error as small as possible the stars should be chosen as near each other in azimuth as is possible. By the use of a mirror in comparing stars, a means recently introduced by C. HOFFMEISTER,¹ the effect of distance will be eliminated, but by the absorption in the mirror other trouble will enter.

A »classical» effect is also the influence of a bright neighbouring star, which acts disturbingly on the observations.

Of special interest for the present investigation is the influence of magnitude and altitude of the two compared stars on the error.

The magnitude of the stars in the moment of comparison — that is the apparent magnitude of either of them plus the extinction — and the corresponding algebraic mean deviation and average deviation were tabulated. (Table 5.)

Table 5. *Relation between the magnitude of the comparison stars in the moment of observation, the algebraic mean deviation and the average deviation.*

Magnitude interval	Algebraic mean deviation	Average deviation	Average deviation after correction	Number of observations		
				Positive residuals	Negative residuals	All
$\leq 1^m00$	$+ 0^m55$	$\pm 0^m55$	$\pm 0^m11$	4	—	4
$1^m01 - 1.50$	$+ 0.08$	± 0.20	± 0.22	2	3	5
$1.51 - 2.00$	$+ 0.04$	± 0.12	± 0.13	5	4	9
$2.01 - 2.50$	$- 0.13$	± 0.21	± 0.18	8	20	28
$2.51 - 3.00$	$+ 0.01$	± 0.19	± 0.19	16	23	39
$3.01 - 3.50$	$- 0.08$	± 0.24	± 0.24	26	33	59
$3.51 - 4.00$	$- 0.05$	± 0.26	± 0.26	33	38	71
$4.01 - 4.50$	$- 0.06$	± 0.27	± 0.27	23	30	53
$4.51 - 5.00$	$+ 0.06$	± 0.28	± 0.27	33	20	53
≥ 5.01	$+ 0.23$	± 0.30	± 0.27	11	4	15

¹ N. RICHTER in AN 256 (1935) p. 77.

We could expect that the fainter the stars are, the greater should the error be. This is especially marked after correcting for the systematical error. For faint magnitudes the systematical error is positive, probably because the bright but diffuse stars are underestimated. The cause is, no doubt, the great difference in extension and in appearance of the stellar images. It is a priori obvious that it must be more difficult to compare a bright star when low with a high and faint star, than to compare two stars of equal appearance. Bright magnitudes also show positive deviations.

Even for the extreme magnitudes the error is not severe, which shows that also for these the method is satisfactory. For the bright magnitudes, below 3^m , the error is less than 0^m20 . For stars apparently fainter than 3^m the error increases and reaches about 0^m30 at 5^m .

As the determination mentioned may be affected by the fact that the fainter magnitudes as a rule arise from observations near the horizon, the relation of altitude to average deviation was examined. It was well seen how the error falls with increasing altitude. The signs of the mean showed no remarkable appearances. The greater error near the horizon might also be influenced by greater unsteadiness of the air at low altitudes.

C. PHOTOGRAPHIC DETERMINATION OF THE EXTINCTION COEFFICIENT.

The influence of the atmospherical extinction and dispersion on photographic results will act in the following ways: —

1) The extension of the images on the plate, caused by the atmospheric dispersion (the atmospherical halo), diminishes the resolvability of objects.

2) a) The loss of light makes a longer exposure necessary for reaching a certain limiting magnitude.

b) The mentioned extension of the images on the plate acts in the same way, and the exposure time for reaching the same magnitude is approximately directly proportional to the square of the diameters of round star images.

3) a) On account of the refraction in the air, the light from e. g. a star will be dispersed and appear as a short spectrum and thus act in the way described in 1) and 2) above.

b) A selective absorption will enter, by which the short waves are more absorbed and dispersed than the long ones. Thus the image of an object approaching the horizon rapidly diminishes in intensity in the extreme part of the short wave region of the spectrum.

Since the value of the extinction coefficient is dependent on the colour of the object photographed and the colour sensitiveness of the plate used, these factors must be considered when the coefficient is determined. As photographic »ordinary» plates are sensitive exclusively to shorter waves, the selective effect mentioned in 3b above will be decidedly prominent for this kind of material. Therefore panchromatic and infra-red sensitized plates will be favoured for objects near the horizon.

For a complete knowledge of the extinction coefficient for different wave-lengths (spectral coefficients), there ought to be measured plates taken in a suitable way e. g. with an astrograph with objective prism. Spectral extinction coefficients were determined by F. E. FOWLE¹ from measurements in the solar spectrum and

¹ Handbuch der Experimentalphysik, Bd 25:1 (1928) p. 229.

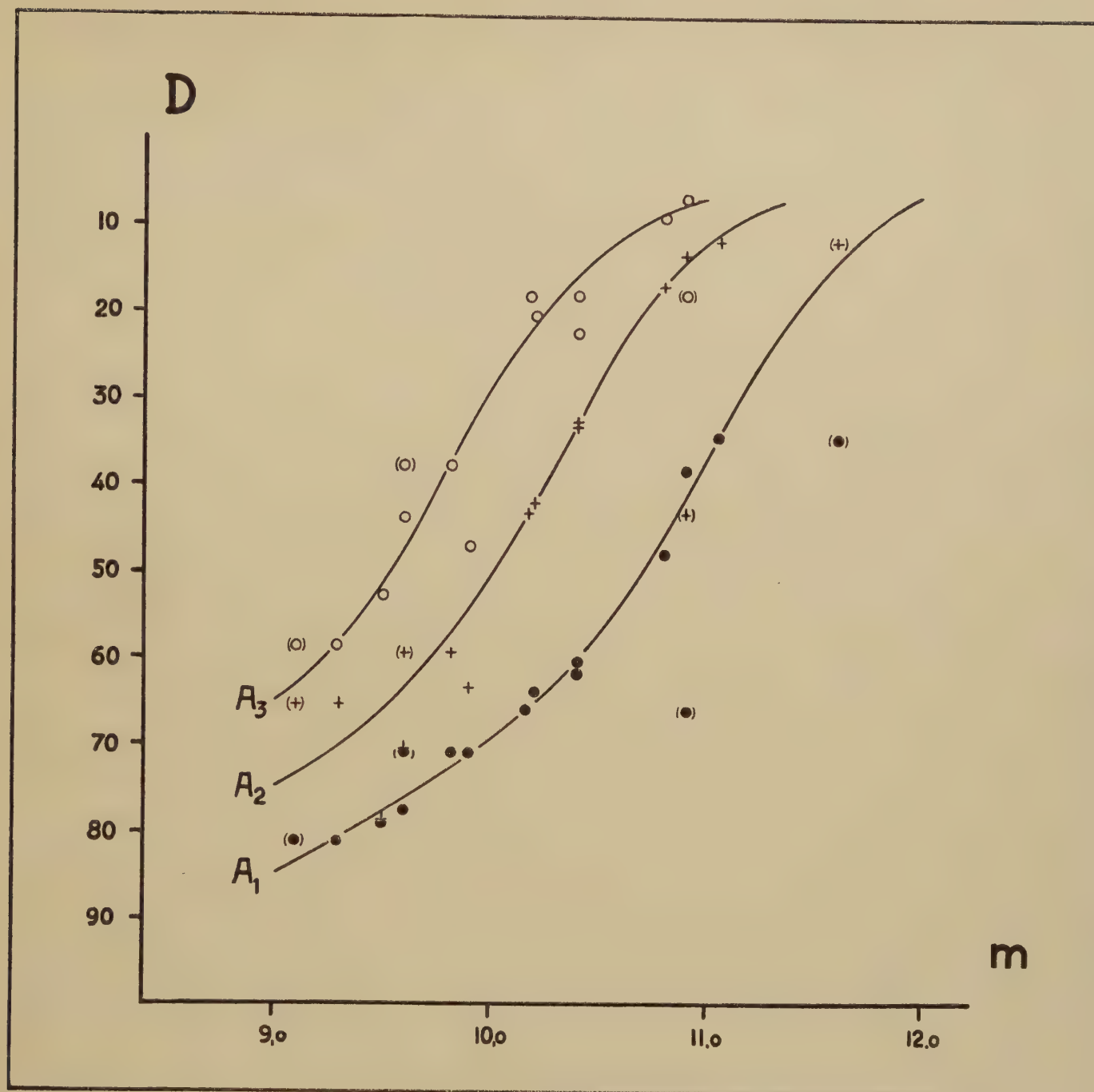


Fig. 2. Diagram showing twelve stars in the Pleiades used for a photographic determination of the extinction coefficient. The three curves represent the three different altitudes during the photography. Measurements performed in a Schilt photometer. (D is expressed in per cent of transmitted light, and m in apparent magnitude).

by E. SCHOENBERG¹ using bright stars. I have not been in a position to make spectral photographs, but have instead tried to determine extinction coefficients with different kinds of plates and for differently coloured stars.

For the subject in question in this paper, however, it is of interest to determine the extinction coefficient only with the same kind of plate as used in nebular photography and on objects with about the same spectral constitution as anagalactic objects. Here I will give such a determination made with an Agfa Superpan plate without filter, exposed in the 30-inch Reynolds reflector on the Pleiades at different altitudes. The faint Pleiades stars measured are of about the same spectral composition (*F* and *G*) as anagalactic objects. Each exposure was 60 seconds, and the date of observation was March 23rd 1935. The night was very clear — visual $f \sim 0.13$ — and the weather steady although windy. The horizon was free from visible haze.

Table 6. *Twelve stars in the Pleiades measured for a photographic determination of the extinction coefficient.*

No	Hertzprung number	Coordinates (1900)		m_{pgH}	Sp	Colour index	Position on plate		Photometer measurements (Per cent absorbed light)			Remarks
		α	δ				x	y	A_1	A_2	A_3	
1	289	3 ^h 40 ^m 12 ^s	+ 23°45.2	10.9	<i>F3</i>	0.32	12.03	15.12	38.56	13.60	7.00	Far from centre
2	388	3 40 43	+ 23 47.6	9.6	<i>F7</i>	0.21	12.27	14.40	77.69	70.90	44.02	Fairly far fr. centre
3	403	3 40 47	+ 24 00.5	10.8	<i>F</i>	0.19	13.55	14.27	48.45	17.31	9.46	
4	468	3 41 13	+ 23 58.0	9.6	<i>F2</i>	0.17	13.30	13.70	70.98	59.65	37.93	Low colour index (C.I.)
5	484	3 41 20	+ 23 49.1	9.1	<i>F5</i>	0.23	12.41	13.54	81.15	65.52	58.62	
6	620	3 41 55	+ 23 38.0	10.2	<i>F9</i>	0.26	11.30	12.70	64.08	42.37	20.75	
7	651	3 41 59	+ 23 47.3	10.4	<i>G2</i>	0.31	12.25	12.55	62.11	33.47	22.53	
8	681	3 42 10	+ 23 50.4	9.9	<i>F5</i>	0.27	12.52	12.38	71.01	63.51	47.21	
9	736	3 42 29	+ 23 44.0	10.4	<i>F9</i>	0.28	11.95	11.95	60.65	32.99	18.34	
10	757	3 42 38	+ 23 52.5	9.5	<i>F8</i>	0.23	12.75	11.75	79.00	79.07	53.02	
11	807	3 42 52	+ 23 57.6	11.6	<i>G5</i>	0.65	13.31	11.42	34.68	11.95	—	High C. I.
12	980	3 43 49	+ 23 56.4	10.9	<i>G8</i>	1.33	13.13	10.13	66.30	43.35	18.23	High C.I. Far fr. centre

The photographic images obtained were measured with a Schilt photometer, but the aperture of this photometer was rather small for the surfaces of the extended stellar images obtained at lower altitudes.

When constructing the magnitude curve of the plate, we have to consider the following systematic errors as the most important ones: —

- 1) Difference in colour index of the stars.
- 2) Different distance of the stars from the optical centre of the plate.
- 3) Different structure of the images (mainly caused by atmospheric halo, imperfect guiding and coma).

The difference in magnitude is independent of the second factor if the images of the different exposures of the same star are near each other on the plate. The twelve Pleiades stars that were measured are found in Table 6.

¹ AN 257 (1935) p. 201.

In Fig. 2 the corresponding magnitude-absorption curves are drawn. The magnitudes and colour indices are those of E. HERTZSPRUNG,¹ the spectra those given by A. SCHWASSMANN.² The principal curve was obtained as a mean of three exposures at a weighted mean altitude of $24^{\circ}0$, the other exposures were at the altitudes $14^{\circ}1$ and $9^{\circ}0$.

With the principal curve chosen as a standard the difference in magnitude for the curves was determined. They were found to be: —

Table 7.

Difference in altitude	Difference in magnitude	Extinction coefficient
$24^{\circ}0 - 14^{\circ}1$	$0^m64 \pm 0^m05$	0.43 ± 0.04
$24.0 - 9.0$	1.13 ± 0.05	0.34 ± 0.02

These values of the extinction coefficient do not agree exactly, but are significant. The most conspicuous disturbing effect on the figures is certainly the different forms of the images of the exposures at the lowest altitudes as compared with the higher ones, and not what also might be expected, a real change in the extinction coefficient between the exposures. The diffuse images obtained on the plates taken at low altitudes were seen to fill up the small aperture of the instrument better, and hence the images absorb more light and give apparently too bright magnitudes. The values of the extinction factor are calculated to correspond to a mean colour index of about $+0.25$ and refer to the red-sensitive Agfa Superpan plate. Four stars — of which Nos. 4, 11 and 12 show much deviating colour indices — systematically deviate from their corresponding curves in Fig. 2, and were corrected by transferring suitable amounts according to the figure. Star No. 5, which was systematically a little wrongly situated, was the fourth. The old places of these are marked by points within brackets.

The photographic value found here agrees well with photographic values of the extinction factor usually found, and is also in satisfactory proportion to the visual value ($f = 0.13$) estimated at the same time.

Generally the factor *two* is accepted for the ratio photographic to visual extinction coefficient. The figure in this actual case is however about *three*.

For a closer examination of the ratio (q) between photographic and visual extinction, which is much disputed, I made the computations found in Table 8. This contains photographic extinction coefficients based on the spectral coefficients given by FOWLE, which are probably the best existing, and on a number of photographic plates tested in Chapter III. The mean sensitivity of the eye is that given in the »Recueil des travaux de la Commission internationale de l'éclairage. Cambridge 1926.»³

Beside the extinction coefficients the corresponding ratios (q) are computed.

Since, owing to a variation of the gradation of a photographic plate with wave-length, which we are going to study more closely in Chapter III, a considerable difference exists if different photographic densities are dealt with, the computations were carried out for some densities: $D = 0.10$ (corresponding to faint nebular densities)

¹ Kgl Danske Vid Selsk Skr, Naturv Afd, R 8: 4: 4 (1923)

² Hamburg—Bergedorf Mitteil 6: 31 (1930) p. 129.

³ Handbuch der wiss und angew Photogr, Bd 4 (1930) p. 8.

Table 8. *Photographic and visual extinction coefficients and their ratios, computed for a number of photographic plates of different type and for varying densities. (Spectral extinction coefficients from FOWLE).*

Spectrum	Visual extinction coefficients	Photographic extinction coefficients and the ratios to the visual coefficients								Density (<i>D</i>)
		Guilleminot Superguil		Agfa Sternplatte		Agfa Isochrom		Ilford Hypersensitive		
	<i>f</i> v	<i>f</i> ph	<i>f</i> ph/ <i>f</i> v	<i>f</i> ph	<i>f</i> ph/ <i>f</i> v	<i>f</i> ph	<i>f</i> ph/ <i>f</i> v	<i>f</i> ph	<i>f</i> ph/ <i>f</i> v	
<i>B</i>	0.103	0.336	3.26	0.320	3.11	0.288	2.80	0.309	3.00	0.10
<i>A</i>	0.102	0.329	3.23	0.312	3.06	0.281	2.75	0.299	2.93	
<i>F</i>	0.101	0.317	3.14	0.301	2.98	0.270	2.67	0.285	2.82	
<i>GO</i>	0.100	0.306	3.06	0.288	2.88	0.259	2.59	0.266	2.66	
<i>K</i>	0.098	0.284	2.90	0.267	2.72	0.236	2.41	0.234	2.39	
<i>M</i>	0.095	0.256	2.69	0.233	2.45	0.183	1.93	0.186	1.96	
<i>B</i>	0.103	0.312	3.03	0.281	2.73	0.276	2.68	0.265	2.57	0.50
<i>A</i>	0.102	0.303	2.97	0.271	2.65	0.265	2.60	0.255	2.50	
<i>F</i>	0.101	0.291	2.88	0.259	2.56	0.251	2.48	0.240	2.38	
<i>GO</i>	0.100	0.277	2.77	0.246	2.46	0.235	2.35	0.222	2.22	
<i>K</i>	0.098	0.258	2.63	0.227	2.32	0.212	2.16	0.194	1.98	
<i>M</i>	0.095	0.234	2.46	0.205	2.16	0.184	1.94	0.159	1.67	
<i>B</i>	0.103	0.291	2.83	0.272	2.64	0.245	2.38	0.241	2.34	1.00
<i>A</i>	0.102	0.282	2.76	0.261	2.56	0.234	2.29	0.227	2.23	
<i>F</i>	0.101	0.271	2.68	0.248	2.45	0.222	2.20	0.212	2.10	
<i>GO</i>	0.100	0.259	2.59	0.233	2.33	0.208	2.08	0.194	1.94	
<i>K</i>	0.098	0.241	2.46	0.213	2.17	0.189	1.93	0.167	1.70	
<i>M</i>	0.095	0.221	2.33	0.192	2.02	0.166	1.75	0.136	1.43	

Table 9. *Photographic and visual extinction coefficients and their ratios, computed for a number of photographic plates of different type and for the density $D = 0.50$. Two reflections against silver mirrors have been considered in the computations. (Compare Table 8).*

Spectrum	Visual extinction coefficients	Photographic extinction coefficients and the ratios to the visual coefficients								Density (<i>D</i>)
		Guilleminot Superguil		Agfa Sternplatte		Agfa Isochrom		Ilford Hypersensitive		
	<i>f</i> _v	<i>f</i> _{ph}	<i>f</i> _{ph} / <i>f</i> _v	<i>f</i> _{ph}	<i>f</i> _{ph} / <i>f</i> _v	<i>f</i> _{ph}	<i>f</i> _{ph} / <i>f</i> _v	<i>f</i> _{ph}	<i>f</i> _{ph} / <i>f</i> _v	
<i>B</i>	0.103	0.284	2.76	0.261	2.53	0.256	2.48	0.250	2.43	0.50
<i>A</i>	0.102	0.275	2.70	0.253	2.48	0.246	2.41	0.240	2.35	
<i>F</i>	0.101	0.266	2.63	0.241	2.39	0.233	2.31	0.225	2.23	
<i>GO</i>	0.100	0.256	2.56	0.230	2.30	0.219	2.19	0.208	2.08	
<i>K</i>	0.098	0.239	2.44	0.213	2.17	0.199	2.03	0.180	1.84	
<i>M</i>	0.095	0.220	2.32	0.199	2.09	0.174	1.83	0.148	1.55	

and the higher densities $D = 0.50$ and $D = 1.00$. The table clearly shows how the extinction coefficients behave for stars of different spectral classes and plates of different types (ordinary, orthochromatic and panchromatic). For stars of different class the following colour temperatures have been chosen: B (22000), A (13000), F (8500), G (6150), K (4400) and M (3200° K).

The decrease of q with increasing density is thus caused by an increase of gamma of the plates with wave-length $\left(\frac{d\gamma}{d\lambda} > 0\right)$. The effect of this can also be expressed so: with increasing density the sensitivity of the plates is transferred to longer wave-lengths.

The variations are considerable for f as well as for q , both having their greatest values for B stars and least values for M stars. What in fact determines the f is the curve resulting from the multiplication of the intensity curve of the star and the sensitivity curve of the plate.

The presence of two silvered mirrors, as is usually and also for the Helwan reflector the case, is introduced in Table 9, dealing only with the density $D = 0.50$.

A result found by E. S. KING¹ and by him denoted as »remarkable» is that the extinction coefficients for stars of widely different spectral classes, α Lyrae ($A0$), α Aurigae ($G0$), α Bootis ($K0$) and α Orionis ($M\alpha$), agreed nearly exactly for photographic determinations. This may be explained from the fact that the region of sensitiveness of the plates used by him was very short, so that the sensitiveness of the plate was of more importance than the change of spectral intensity of the stars photographed.

It could also have been so that the bluer stars (brighter and photographically more active) in his method of out-of-focus images, were of the higher densities, in which case a compensation of the effect of spectral class probably has taken place.

W. DIECKVOSS² finds the ratio photographic to photovisual (not visual) extinction coefficient = 1.49. This agrees well with the value 1.7, which is obtained if we use the spectral coefficients given by FOWLE and the sensitivity curve of the Agfa Astroplatte as given by DIECKVOSS. The latter gives however a spectral sensitivity curve for this plate which is very peculiar, almost missing sensitivity in the short end of the visible spectrum. The curve according to him has its maximum at $\lambda = 4750 \text{ \AA}$ and falls nearly equally at both sides, an appearance which looks as if a yellow filter had been used.

If in connection with nebular photography the numerical value of the extinction coefficient is wanted, it seems to me better to determine the coefficient visually, and the value found may afterwards be converted into photographic measure.

In doing this we have to pay attention to the spectral sensitivity of the plate used as well as to the density which is in question for the nebulae. If the visual coefficient was not determined by using G stars — or G stars as a mean — a correction can be applied with the help of the mentioned table.

The visual method used in the previous paragraph is a rapid one and can be applied without any instrument or plate. Thus it can always be practised in connection with nebular photography, estimates being made e. g. before and after an exposure. A numerical value about the state of the atmosphere is always preferable to mere description, even if excellently detailed.

¹ Harvard Ann 76 (1916) p. 99.

² Hamburg—Bergedorf Abh 4:3 (1935) p. 53 = A N 255 (1935) p. 117.

CHAPTER II.

THE 30-INCH REYNOLDS REFLECTOR.

A. THE INSTRUMENTAL HALO WITH SPECIAL REGARD TO THE REYNOLDS REFLECTOR.

The utility and the result of astronomical photography in general depend in the highest degree upon the instrument used. The instrumental halo includes the expansion of images, which is caused by a number of factors, of which I classify the most important ones in the following way: —

Properties of the mirror: optics of the mirror, diameter, focal length, coma, curvature of the field and flexure of the mirror.

Properties of the instrument which may be corrected before photographing: state of the mirror's surface, the tilt of the optical axis and the driving of the clockwork.

Properties of the instrument which are in the hands of the observer when photographing: the focusing and the guiding of the instrument.

These factors must always be taken into account when considering the resolving power.

I will not deal with the important, that is true, but also well-known part that the dimensions and the general qualities of an instrument play, but restrict my examinations to the 30-inch Reynolds reflector of Helwan. A detailed description of the instrument and its mounting has been given by its donator, J. H. REYNOLDS.¹ The most important part of the instrument, the parabolic mirror, is not however the original one, but one received in 1914, which was constructed by G. W. RITCHEY. A thorough examination of the optical qualities of the mirror has been performed by W. S. ADAMS,² who made photographic determinations of the focal length for selected zones according to the HARTMANN method. The greatest difference found between computed and observed focal length amounted to 0.08 mm, but this was in the central part of the mirror, which, however, in the use of the telescope is covered by the flat. For the outer zones the maximum difference was about 0.04 mm. From the tests by ADAMS the main result acquired is that the agreement between computed and theoretical values for the different zones of the mirror is so close that the differences found lie near the limit of the exactness of the measurements. »The mirror may accordingly be regarded as essentially perfect to within the limit defined in this way.»

The properties that determine the power of collecting light and the resolving power of the reflector are the diameter (76 cm) and the focal length (343.2 cm). The angular aperture is thus nearly $F: 4.5$, a rather high power, even for a reflector used for nebular photography like this one. For a parabolic mirror with the angular aperture $F: 4.5$ the greatest errors, the coma and the curvature of the field, that affect the appearance of the images produced by it, are shown in Table 10.

¹ MN 67 (1907) p. 447.

² Helwan Bull 12 (1914) p. 91.

Table 10.

Field	Coma	Curvature of field
0°10	1°7	0°0
0.25	4.2	0.2
0.50	8.4	0.9
0.75	12.5	1.9

For such small distances from the optical centre as are covered by the Helwan-plates (8.2×10.5 cm, with $1 \text{ mm} = 1'$), we see that the coma is the dominating error. The table, which is constructed by interpolating in a classical table given by K. SCHWARZSCHILD,¹ deals with normally exposed star images. If we have a plate of high contrast, the coma will be relatively less than for a plate of low contrast. Such differences in coma and other similar errors — based on differences in contrast and density of the stellar and nebular objects measured — were discussed by K. LUNDMARK² for the explanation of apparently great position effects measured in the direction of the arms of spirals.

Table 11.

Error in focus	Increase in diameter of cone	Total diameter of cone	Loss of magnitude
0.010 mm	0°13	0°40	0 ^m 9
0.025 »	0.33	0.60	1.7
0.050 »	0.66	0.93	2.7
0.075 »	1.00	1.27	3.4
0.100 »	1.33	1.60	3.9
0.250 »	3.32	3.59	5.6

Owing to the great angular aperture, the requirements for a good focus are also considerable, as I show in Table 11, which has been computed from the properties mentioned above, from the scale in focal plane $1' = 1.00 \text{ mm}$ and from a theoretical diameter of diffraction disc of a star $= 0''.27$. The theoretical value of the diffraction disc has been computed by the use of the difference in focal length for different zones amounting to 0.04 mm , found by ADAMS. In this connection it is also supposed that the distribution of light in the images is uniform. The value $0''.27$ is in any case not too small.

The table shows, for slight errors in focus of the Helwan reflector, the theoretical loss in magnitude per unit area in the cross section of the luminous cone where it intersects the photographic emulsion. A similar table valid for the 60-inch telescope of the Mt Wilson Observatory has been published by G. W. RITCHEY,³ whose considerations are also valid for the present table. He says: »As shown by the table this loss (of magnitude)

¹ Göttingen Mitteil 10 (1905) p. 11. ² Upsala Medd 30 (1927) p. 46.

³ Mt Wilson Contr 47 (1910) p. 5 = ApJ 32 (1910) p. 30.

is so great that the surface-intensity must certainly lie below the threshold value for large numbers of faint stars which under conditions of perfect focus would still be impressed on the photographic plate. — — —

»While atmospheric conditions seldom or never permit the theoretical condition corresponding to perfect focus to be realized, still the table shows the enormous importance of the utmost attainable accuracy of focusing when we are dealing with large angular apertures.»

The smallest dimensions of the photographic images obtainable have already, owing to the atmospheric dispersion and changes in the atmospheric conditions, a limit of $0''.9$. The following table (Table 12), therefore, is presumably much nearer the truth, as it is based on stellar images in the best focus of $2''.0$.

Table 12.

Error in focus	Increase in diameter of cone	Total diameter of cone	Loss of magnitude
0.025 mm	$0''.33$	$2''.33$	$0^m.3$
0.050 »	0.66	2.66	0.6
0.100 »	1.33	3.33	1.1
0.200 »	2.66	4.66	1.8
0.400 »	5.32	7.32	2.8

Anyway, for good Helwan plates the diameters of the stellar images are less than $3''$. An idea of what is most common for stellar diameters appears in Table 13, which is based on measurements of limiting magnitude stars on 50 nebular plates exposed in a normal way.

Table 13.

Diameter limits	$2''.0-2''.9$	$3''.0-3''.9$	$4''.0-4''.9$	$\geq 5''.0$
Number	6	34	10	0

The deviation from a circular form of the photographic image, based on flexions of one of the mirrors, has recently been examined by A. COUDER.¹ If a mirror is fixed in its position by means of screws attached at certain points, there will enter pressures from these points that will disfigure the surface of the mirror; a maximum effect occurring when the axis is vertical. For the form of focal and out-of-focus images, I refer to the instructive diagrams of the paper cited. In the case of the Helwan reflector the images were as a rule somewhat triangular in shape, especially for slightly out-of-focus images, owing probably to the fact that the flat mirror was fixed at three points. With regard to the resolving power, it is evident that a triangular image obtained instead of a circular one (which occupies the least possible surface) means a diminishing.

¹ Bull Astr 7 (1932) p. 201. See especially the figures 29 and 30.

Instrumental errors, dependent on some qualities of the reflector which may be adjusted *before* photographing, are: state of the mirror's surface, the tilt of the optical axis, and the driving of the clockwork. A desideratum for coming work with the Reynolds reflector is that a clockcontrol should be attached to the driving work of the reflector. Another wish is that the mirrors might be aluminized, to better stand against the content of sulphuric gases frequent in the atmosphere at Helwan. The coating of the mirrors is of great importance also with regard to spectral absorption when we deal with spectral properties of the objects. Also in parts of the present paper the selective absorption of the mirrors has been accounted for. In such cases there is assumed that with regard to the Reynolds reflector for the silver mirrors reflection curves are valid of the same sort as is given by E. HAGEN and H. RUBENS.¹ As compared with aluminium the silver surface shows a considerable absorption in the short end spectrum, with a maximum of about 96 % at an approximate wavelength of about $\lambda = 3150 \text{ \AA}$. A much more uniform absorption is given by the aluminium surface.²

In particular with regard to the personal side of the photographic technic, whether for the photography of stars or nebulae, it must be said that the observer has to carry on an everlasting and hard struggle, not only to gain the best possible focus but also to keep it. And moreover, he has to handle the guiding of the instrument, always most exacting work.

The method of focusing used at Helwan is the well-known knife-edge test, introduced by J. B. L. FOUCAULT³ and refined by RITCHEY.⁴ The exactness of this method depends only on the optical qualities of the mirrors and on the atmospheric conditions when the test is made. Tests of the exactness of the method carried out by me for stars brighter than 6^m have shown that the exactness for such bright stars lies within a range of 0.06 mm, corresponding to a turning of 1/20 of a revolution of the capstan head. For stars fainter than this magnitude it is difficult to focus with greater certainty.

In focusing work it is profitable for the accuracy to make two tests on the star and to choose the mean of the readings. In this, one of the tests should be made by turning the capstan head from the right and one from the left, because there is a tendency of the observer to turn too much (or possibly too little) in the test. I myself and A. H. SAMAHA at Helwan generally used to pass the right focus. Such an effect may either be due to the fact that the observer will be somewhat »tired» of observing the dark shade appear several times from the same side, and, therefore, when the focus is gained, more easily goes too far in turning; or it may be explained in this way — that the capstan head is turned discontinuously, and that the observer will stop it in a position when it is proved at least to have reached the focus. For this effect see the observations Nos. 801—875 in Appendix II.

The knife-edge test has the great advantage that it is rapidly carried out. There is however always the chance that the position of the knife-edge in the plateholder will not quite coincide with the plane in which the emulsion of the photographic plate, or better, the main mass of the relatively thick emulsion, will fall. For this reason the knife-edge test must at times be compared with a number of photographs of stars taken at distances around the supposed position of focus. For this reason I have made use of the good method of covering the flat with a piece of cardboard in which a triangular hole was cut. A series of photographs of a star inside

¹ Annalen der Physik 8 (1902) p. 16.

² LANDOLT-BÖRNSTEIN: Phys.-Chem. Tabellen, Erster Erg.-Bd, 5. Aufl. (1927) p. 463.

³ Paris Ann 5 (1859) p. 203. ⁴ Mt Wilson Contr 47 (1910) p. 4 = ApJ 32 (1910) p. 29.

and outside the right focus will show how the small triangular image turns upside down just as the focal plane is passed. For an astrograph this method has been frequently used at Lund.

If the photography is to be done with the use of, for example, a yellow filter, the displacement caused by this filter will best be determined by a series of photographic test images. The calculation of the displacement from the known refraction index of the filter glass and the thickness of it may serve as a control.

Now the fact is that the knife-edge test in case of tensions in the points of support of the great mirror or of the flat, as have been mentioned on p. 30, can give erroneous results. A method independent of the effect of such torsions is given by M. WOLF.¹ This method has been applied to the focusing of, among other instruments, the 1.22 m reflector of Berlin-Neubabelsberg, where I have had the opportunity of studying it closely. I take the liberty to cite here some lines from a P. M. on the use of the method written for me by Dr H. KÜHLBORN: »Eine planparallele Glasplatte mit einem fein aufgeritzten Strichnetz wird an Stelle der Kasette so befestigt, dass die Ebene der Striche genau in der Ebene der photographischen Schicht zu liegen kommt. Auf die Striche fokussiert man sich ein Okular scharf (bei 8.4 m Brennweite unseres Spiegels nehmen wir ein orthoskopisches Okular von 25 mm Brennweite). Dann muss man sich einen in der Nähe des zu photographierenden Objektes stehenden hellen Stern aussuchen (bei uns nicht schwächer als 8^m.5 bis 9^m.0) und sich nun diesen Stern auf die Striche fokussieren; hierbei darf natürlich der Abstand von Strichplatte zu Okular *nicht* mehr verändert werden, vielmehr ist der ganze Beobachtungsauszug hin und her zu bewegen. Hat man eine starke Vergrösserung, so lässt sich der Stern sehr bequem auf die Striche fokussieren. Nach einiger Übung kann man sehr sicher fokussieren. Bei der langen Brennweite des Babelsberger Spiegels bekommt man noch bei mittelmässigen Bildern den Fokus auf 0.1 mm genau, was gänzlich ausreicht bei der langen Brennweite.»

B. CHANGES OF FOCAL LENGTH OF THE REYNOLDS REFLECTOR.

The most important factor acting on the focal length of a reflector is no doubt temperature. Among those who have closely investigated instruments and instrumental constructions from this point of view are to be mentioned before others G. W. RITCHEY,² W. H. WRIGHT,³ C. D. PERRINE⁴ and A. DANJON and A. COUDER.⁵ These observers also stress clearly the great importance the knowledge of the change of the focal distance has for the quality of the photographic images to be obtained, and hence also for the resolving power of the instrument. PERRINE for example calls attention to the importance of the knowledge about the instrument's thermal change, to be used for correcting the focus without refocusing. He says: »A large mirror can be approximately kept at a constant temperature, but not the tube of the telescope. In many cases these changes of focus interfere greatly with the quality of the photographs and attempts to correct for them by testing the focus visually cause appreciable interruptions in the exposure.

¹ This method is probably unpublished (I am thankful to Dr K. REINMUTH, Heidelberg, for information about the method).

² L. c., p. 26.

³ Lick Publ 9 (1907) p. 23.

⁴ PASP 30 (1918) p. 55.

⁵ Lunettes et Télescopes (1935) p. 578.

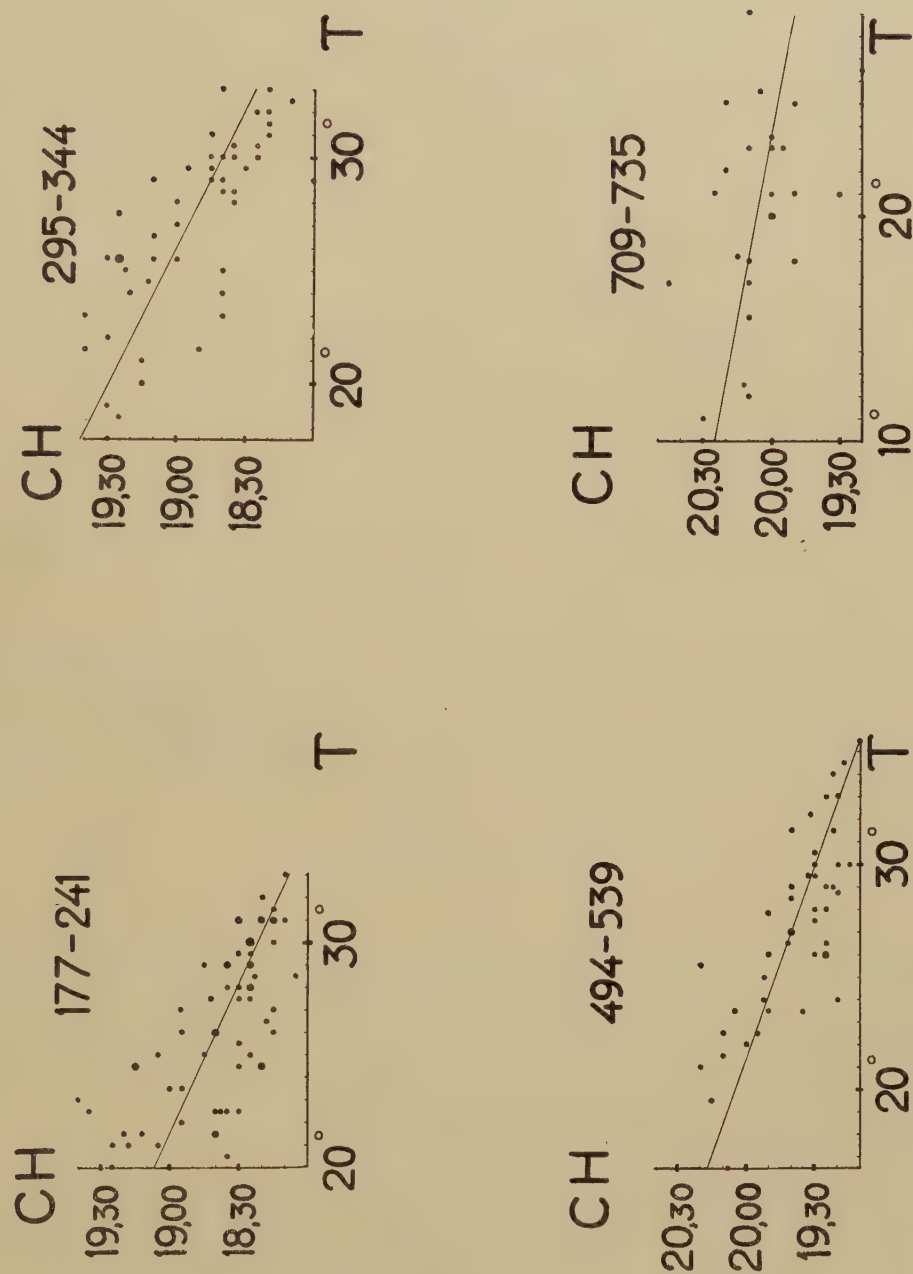


Fig. 3. Relations between reading of capstan head (CH) of the Reynolds reflector and temperature (T) in the dome at the moment of observation. CH , which stands for apparent focal length, is expressed in whole revolutions and sixtieths of a revolution. Each point group represents a time interval between two silverings of the mirrors.

»If the telescope mounting is stable (and the changes of focus not too great) they may be almost entirely allowed for without interrupting the exposures, by the use of focusing screws, which are easily worked and provided with micrometer attachments, in connection with a thermometer or two placed at critical places about the telescope, the reading of the focusing micrometers being corrected by means of a previously prepared table whenever sufficient changes in the thermometer occur.»

If it also can be said that the influence of temperature on the focal length is fairly well known in general, the numerical relation seems anyway not to have been investigated by observation series to any great extent. As for the Reynolds reflector, I have had the opportunity of making such an investigation thanks to the very thorough and extensive series of observations carried out by the Helwan observers, especially H. KNOX-SHAW, C. C. L. GREGORY and M. R. MADWAR. The catalogue published here in Appendix II contains 800 observations of focus by these observers, carried out during 1915—1934; and further 75 similar observations made by me in 1934—1935 and numbered 801 to 875.

The interval of temperature covered by the observations lies between $+5.5$ and $+35.5$ C, a rather satisfactory interval. Each time a resilvering of the mirrors has been made, there is an empty line in the catalogue, separating the observations made before the silvering from those after.

A closer examination of these observations shows that within each interval of time between two resilverings, the individual points marking the relation between temperature and reading of the capstan head are, as may be seen by a mere inspection, fairly well grouped along straight lines. Four examples are collected in Fig. 3. Along the absciss-axes is plotted the temperature (T), and along the ordinate-axes the reading of the capstan head (CH).

If the positions of the different point groups are compared, it is found that at every resilvering there enters a marked jump, while the direction of their slope remains rather unchanged. The different lines representing the groups of points are thus systematically displaced to each other in direction of the CH -axes. The slope of the different lines and its relation to the temperature will be investigated more closely below.

Denote the equation of a line

$$CH = \alpha + \beta \cdot T$$

where β means the angular coefficient and α the ordinate in the origin. With the method of least squares the coefficients α and β have been determined for the different lines. They are tabulated in Table 14, where among other values the weights of the point groups are also given. All figures related to the reading of the capstan head are expressed in integer numbers of rotations and sixtieths. After the weights of the β -values had been computed, the mean slope of the lines was determined. It was found that

$$\bar{\beta} = -0.0435 \pm 0.0117$$

It is however of little use to undertake the translation of the different groups to a common line, because, as will be seen from Fig. 4, a correlation between β and T exists. The latter quantity is given as the mean temperature of the point groups.

Table 14. *Some figures related to the tests of focus of the Reynolds reflector, after grouping into intervals between silverings.*

No	n	T_m	CH_m	$\beta \pm \epsilon (\beta)$	α	p (β)	ΔCH
1—63	63	14.9	19; 27	-0.0939 ± 0.0176	20; 52	589	$-0; 06$
64—79	16	20.7	18 47	-0.0564 ± 0.0711	19 57	42	$+0 19$
80—141	62	27.3	18 40	-0.0469 ± 0.0115	19 57	452	$+0 08$
142—176	35	17.3	18 34	-0.0218 ± 0.0109	18 57	437	$+0 40$
177—241	65	26.5	18 38	-0.0753 ± 0.0093	20 37	796	$+0 13$
242—294	53	16.3	19 23	-0.0394 ± 0.0088	20 01	1117	$-0 05$
295—344	50	26.9	18 54	-0.0821 ± 0.0126	21 07	781	$-0 05$
345—384	40	14.3	19 14	-0.0672 ± 0.0101	20 12	433	$+0 09$
385—405	21	21.1	19 11	-0.0023 ± 0.0235	19 14	197	$-0 06$
406—431	26	16.3	19 20	-0.0788 ± 0.0084	20 37	336	$-0 02$
432—466	35	26.1	18 52	-0.0334 ± 0.0065	19 45	893	$-0 01$
467—493	27	18.0	19 33	-0.0386 ± 0.0118	20 15	213	$-0 20$
494—539	46	27.2	19 39	-0.0588 ± 0.0070	21 15	751	$-0 50$
540—564	25	19.0	19 16	$+0.0362 \pm 0.0316$	18 35	191	$-0 06$
565—582	18	28.1	18 55	-0.0590 ± 0.0152	20 34	101	$-0 08$
583—599	17	16.2	18 51	-0.0515 ± 0.0097	19 41	304	$+0 26$
600—610	11	27.6	19 17	-0.0702 ± 0.0222	21 13	110	$-0 29$
611—630	20	21.4	19 10	$+0.0143 \pm 0.0118$	18 51	438	$-0 06$
631—684	54	29.3	20 25	-0.0834 ± 0.0125	22 52	780	$-1 41$
685—708	24	24.2	20 30	-0.0063 ± 0.0083	20 39	1036	$-1 33$
709—735	27	19.7	20 07	-0.0307 ± 0.0094	20 43	655	$-0 58$
736—766	31	28.7	19 16	$+0.0310 \pm 0.0297$	18 23	294	$-0 31$
767—781	15	24.4	20 42	-0.0362 ± 0.0130	21 35	622	$-1 46$
782—800	19	26.9	18 37	-0.0243 ± 0.0111	19 16	596	$+0 13$

The size of the surfaces in the figure is proportional to the weight of β given in the seventh column of Table 14. With the method of least squares a curve of the second degree was laid through the points. The equation of this curve was found as follows

$$\beta = -0.01362 - 0.000656 (T - 22) - 0.001195 (T - 22)^2$$

The maximum of the curve, $\beta = -0.01353$, corresponds to $T = 21.73$. Thus, the curve does not quite reach the zero of β , which, of course, would have been most favourable from the point of steadiness of the focus with a change of T in the mean temperature region.

With the help of this curve it is now easy to find the relation between CH and T .

If the relation

$$dCH = \beta dT$$

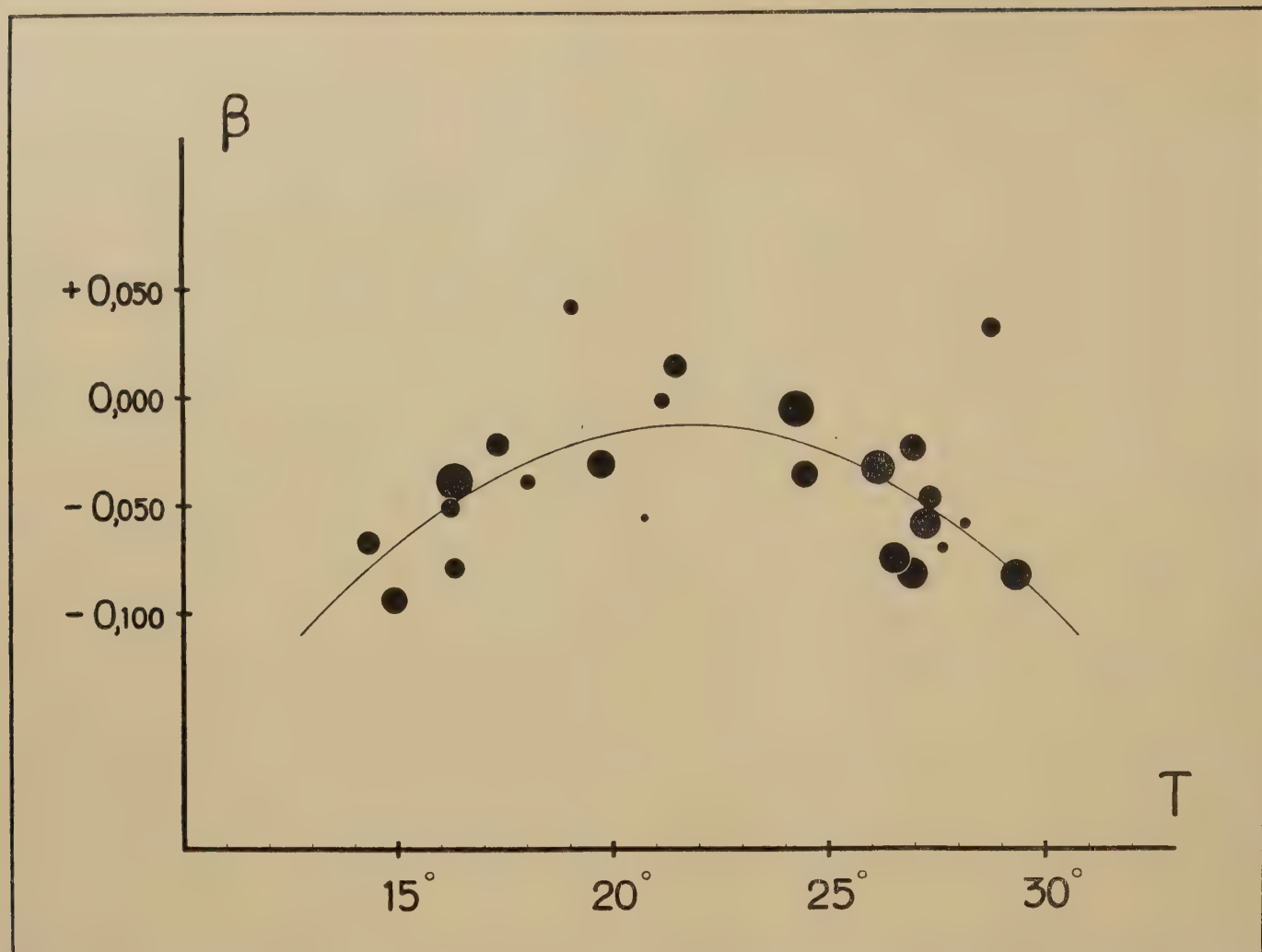


Fig. 4. The connection between the slope (β) of the thermal change of focal length of the Reynolds reflector and temperature (T).

where β is the above mentioned function of T , is integrated, we arrive at an expression of the form

$$CH - CH_0 = \beta_0 T + \frac{1}{2} \beta_1 (T - 22)^2 + \frac{1}{6} \beta_2 (T - 22)^3$$

The coefficients have the same values as above

$$\begin{aligned}\beta_0 &= -0.01362 \\ \beta_1 &= -0.000656 \\ \beta_2 &= -0.001195\end{aligned}$$

This curve of the third degree is drawn in Fig. 5. For CH_0 , a constant that can be arbitrarily chosen, was adopted the numerical value

$$CH_0 = 18 \frac{56}{60}$$

Now the different groups of points have been displaced vertically so that their centres of gravity lie on the curve. Within the region $17^\circ - 27^\circ$ the curve is nearly a horizontal straight line. The variation of CH per degree is here only

$$(\Delta CH)_{1^\circ C} = -\frac{0.9}{60} \text{ of a revolution.}$$

Outside these limits the variation of CH is much greater. Within the nearest temperature interval of 10° at both sides we find in mean

$$(\Delta CH)_{1^\circ C} = -\frac{8}{60} \text{ of a revolution.}$$

In Fig. 5 the effect of the change of the telescope, which generally appears after the resilvering of the mirrors, is eliminated, and all points may be treated as if they referred to one single interval of time, and no resilvering had taken place.

It may be of some interest to consider the amount of the displacements of the centres of gravity of the point groups, because these replacements are a measure of the exactness with which the instrument will recover its normal position after every dismounting of the mirrors. In the last column in Table 14 the displacements (ΔCH) are given. In most cases these displacements only amount to $\Delta CH = \frac{10}{60}$ of a revolution,

corresponding to a change in apparent focal distance of 0.2 mm. In some cases the displacements will reach ten times this amount. Yet it must be pointed out that this is still to be considered as a small quantity.

The somewhat varying thickness that the silver film will receive on the mirror may be considered not to affect the observed differences in focus.

It is also of interest to use the previously discussed curve in order to examine in what degree the observed changes in apparent focal length will agree with the changes theoretically computed. As we know that a revolution of the capstan head corresponds to 1.41 mm,¹ the apparent change in focal length is for the central interval $17^\circ - 27^\circ$:

$$\Delta F = -0.021 \text{ mm/degree } C$$

and for the ten-degree intervals outside the former one

$$\Delta F = -0.188 \text{ mm/degree } C$$

We now compare these values with those theoretically derived, and assume that account is only taken of a homogeneous dilatation by temperature of the mirror and the tube. The apparent relative change in focal length is, as easily may be shown,² obtained from the equation

$$\Delta F = F (a - a') \Delta T$$

¹ Helwan Bull 12 (1914) p. 97.

² See e. g. DANJON & COUDER, l. c., p. 578.

Here F means the focal length of the mirror, ΔT the increase of temperature and α and α' the dilatation coefficients of glass and iron respectively. Assuming that $\alpha = 7.5 \cdot 10^{-6}$ and $\alpha' = 11 \cdot 10^{-6}$, we get

$$\Delta F = -0.012 \text{ mm/degree } C$$

which is only half of the observed amount in the best region.

The explanation of the discordance between these two quantities is certainly to be found in the facts earlier noticed by WRIGHT¹: that the relatively large mass of the parabolic mirror receives the temperature of the surrounding air only slowly, and by PERRINE²: that an uneven distribution of temperature in the glass mass of the mirror will cause tensions, followed by changes in focal length. From my results found above it must therefore be supposed that these severe tensions mostly enter outside the favourable interval 17° to 27° for the Reynolds reflector. DANJON and COUDER say of the 81 cm mirror in Forcalquier that the ratio between observed and from the mentioned formula computed change was about ten, which agrees well with the mean value of the greater range of temperature found here for the Helwan reflector. The most important factor for these circumstances may be the thickness of the big mirror.

If we look at the theoretical equation giving the change of focal length, we see that a value corresponding to the observations is found, if the dilatation of the mirror is quite neglected in relation to that of the iron construction. This might be interpreted in the following way, which is accordant with the result of WRIGHT above: that the big mirror will not in reality follow the variation in temperature of the surroundings, but remain at a more constant temperature.

Considering the small thermal conductivity of glass, there is much reason to suppose that a large, thick mirror, well isolated, will only take the temperature of the surrounding air very slowly. Also we know that a polished silver mirror very well reflects the long, visible rays and the radiation of heat.

In fact, we have reason to suppose that an average between these two extremes will predominate. The mirror has during the evening and the night a temperature which is higher than that of the iron, and it will more slowly decrease and thus remain considerably more constant. Instead of the previous equation for the change in focal length, we should have

$$\Delta F = F\alpha\Delta'T - F\alpha'\Delta''T$$

where thus $\Delta'T$ (glass) and $\Delta''T$ (iron) are different, and $\Delta'T < \Delta''T$ during an observation night. The significance of an assumption of this kind would best be tested by a real measurement of temperature of the main mirror as well as that of the iron construction and the air. Such a measurement was beyond me at Helwan, as it requires quite special thermometer arrangements.

With regard to the observations examined in the present investigation, that factor must be contributive to the dispersion of the points around the mean line and also varying, because the observations are distributed over a very great number of nights, with very unequal falls of temperature per unit time. In spite of this the relation between apparent focal length and the temperature of the reflector, as we have seen, is well marked.

¹ Lick Publ 9 (1907) p. 23.

² PASP 30 (1918) p. 55.

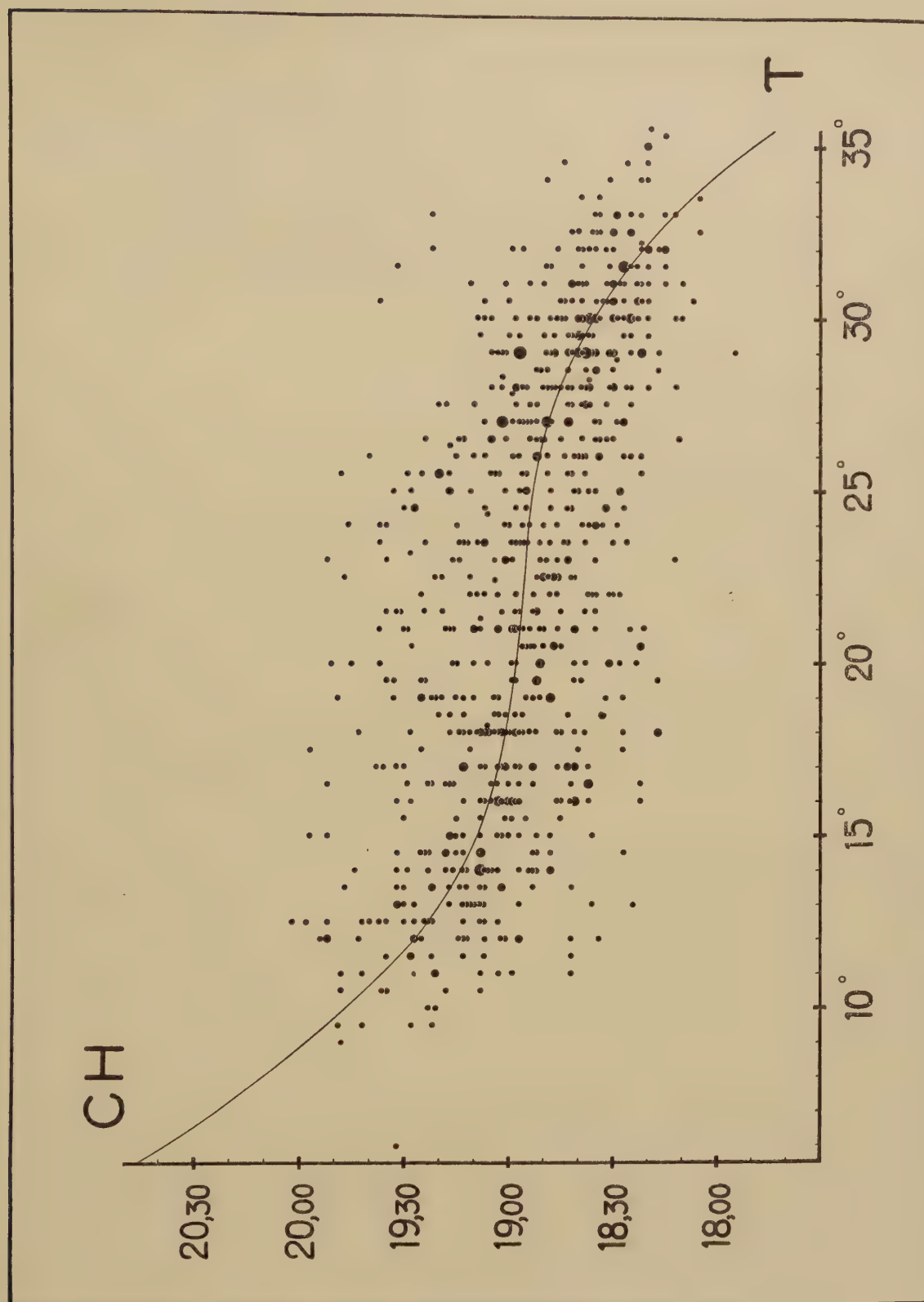


Fig. 5. Diagram showing the variation of apparent focal length of the Reynolds reflector — reading of capstan head (CH) — with temperature (T).

Another method of stating the validity of the previously mentioned equation would be to correlate the distances of the different points from the curve in Fig. 5 — regard taken to their signs — with, for example, the mean temperature during the day before the observations. This mean temperature is thus supposed to represent the excess of temperature to be expected in the main mass of the mirror. Another factor, expected suitable, would be the rapidity of decrease of temperature while observing. I hope to have the opportunity of entering further into this question in a later work.

A proposed relation between apparent focal length and the position (altitude or azimuth) of the instrument has been examined. The influence of position is evidently not very great, although it was possible to trace it. By relating the differences of the individual points from the curve in Fig. 5 to the altitude of the instrument in the moment of focusing, it was found

$$\frac{\Delta CH}{\Delta \text{Alt}} = \frac{2}{60} \text{ of a revolution per } 10^\circ \text{ difference in altitude,}$$

which means a change in focal length of 0.045 mm per 10° difference in altitude. Owing to the relatively large dispersion of the points, the relation between focal length and altitude is much masked. Anyhow, the effect seems to be significant. Further, the interval of altitudes for most points is fairly narrow, about 20° — 50° . The relation is linear. In accordance with what is found, there is reason to expect that the focal length of a reflector, which is hanged up in its lower part, apparently decreases for lower altitudes, a decrease caused by the stretching of the iron construction.

It is of importance closer to observe the variations of the focal length during one and the same night. For such an investigation I have made use partly of the observations in the above-used catalogue, performed during one night, partly of a number of my own observations, published as Nos. 801—875.

The first mentioned observations amount to 89, distributed on 37 nights, but as in some cases the temperature differences are too small for a real change in CH to be observed, a great number of them are of less use.

If for every night of observation, when a difference in temperature of $\Delta T \geq 2^\circ$ separates the focus tests, we form $\beta = \frac{\Delta CH}{\Delta T}$, we get

$$\bar{\beta} = -0.091 \pm 0.023 \quad (n = 15)$$

The same computation with $\Delta T \geq 1^\circ$ gives the much less value

$$\bar{\beta} = -0.036 \pm 0.017 \quad (n = 38)$$

My own observations amount to 75, distributed on 5 observation nights, and are marked out in Fig. 6. All of them have been made in a period when no resilvering of the mirror was performed. The slope of a line placed graphically through all the groups of points had the value

$$\beta = -0.095$$

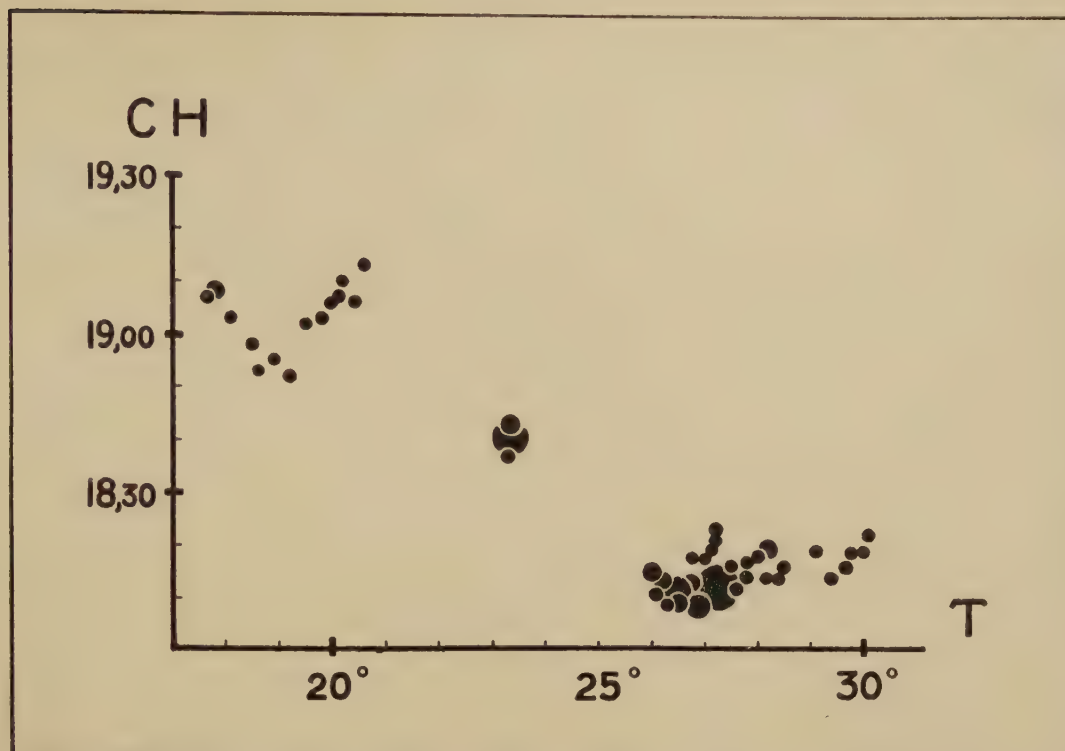


Fig. 6. Seventy-five tests of focus for the Reynolds reflector, distributed on five observation nights.

which is in satisfactory agreement with the results found before. The mean temperature for these tests was 25.3°C . The slope during one and the same night does not, however, seem to agree with this main direction.

The observations of Aug. 14th, 16th and 30th 1934 are grouped between $T = 26^\circ$ and $T = 30^\circ$ with a slight falling tendency of CH with lower T . The interval of time is here rather short.

The observations of Aug. 15th 1934 and March 11th 1935, which extend over rather long intervals of time, with decreasing T at first decrease in CH , but increase afterwards.

This statement completely agrees with what previously was found for the greater material, where more than one focus test was had in the same night. In fact $\Delta T \geq 1^\circ$ includes short interval of times (corresponding to a numerically small β), and $\Delta T \geq 2^\circ$ means somewhat longer intervals of time (corresponding to numerically large β).

These statements forward the following theory of the behaviour of the reflector, which is in agreement with the previously given theory, dealing with two terms (glas mirror and iron construction) contributing to the observed focal distance:

1) Dome left open for a while. Temperature of iron construction rapidly approaches temperature of the air, which in the dome approaches that of the air outside the building.

2) Knife-edge tests are started. The temperature of the mirror decreases relatively rapidly, and first after a certain time it will approach that of the iron construction. β is positive or negative and numerically low.

3) After a certain time the temperature of the mirror has approached that of the iron, and ΔT decreases. Herewith the negative β numerically increases.

An eventually suspected backlash in the capstan head screw, from the very agreeing repetitions of focus reading is seen probably to be so small that it will not affect the results.

The following question is quite naturally asked: — How often must a refocusing be performed to get the best possible images? In this question we include the alternatives that a new determination of the focus is made (knife-edge test), or that the focus is corrected, after the temperature has been read off, and with knowledge of its influence upon the apparent focal length.

As shown by the observations the temperature in the dome of the Helwan Observatory usually decreases at least 1°C per hour during the observation night. Sometimes this fall may amount to 3°C per hour or even more. From what has been shown above, a change of 1°C corresponds in the less favourable temperature regions to a turn of the capstan head of about $3/60$ of a revolution. As the error in the focusing usually amounts to this value, it is clear that it is no use refocusing every hour when the fall in temperature is that mentioned. But after two or three hours the change has grown so great that a refocusing is profitable. If one wants to make use of the computed change in apparent focal length and neglect refocusing (knife-edge test), the variation of the focal length requires further investigation.

CHAPTER III.

THE PHOTOGRAPHIC PLATE.

A. THE REFLECTION HALO.

The resolving power of photographic plates is often associated with the two kinds of halo which are called the reflection halo and the diffusion halo, of which the latter is by far the most important. In reality the reflection halo, which can be wholly eliminated by backing the plate or by inserting an intermediate slow emulsion or colour layer, has lost its importance, at least for such faint intensities as we are generally dealing with when photographing nebulae. The different problems of the reflection halo: its cause, the computation of its diameter, and the relative distribution of intensity in it, are also now well known. Therefore my work on the reflection halo will be restricted to its history, which I hope will be of some interest, since it still seems to be incompletely known. I shall also show a reflection halo of a peculiar form found around some star images on a Helwan plate.

History of the reflection halo. While the knowledge of the diffusion halo can easily be traced back to the very first years of photography¹ (the daguerreotype process), this cannot, of course, be the case with the

¹ For example H. BÄCKSTRÖM in Nord tidskr f fotogr (1919) p. 104 mentions the observation of a halo on a daguerreotype from 1840.

reflection halo, as this latter phenomenon requires the presence of a transparent glass or film. Not until a decade after the improvement of the first photographic method, which used silvered copper plates, did the glass plates come into use in the albumin and collodion methods. But still one decade more had to pass before the first investigations on the reflection halo appear, being from about 1860. By no other investigator on the present subject have I been able to find it traced back so far.

The modern »Handbuch der wiss. und angew. Photographie»¹ says that A. CORNU² and E. v. GOTHARD³ explained the causes of the reflection halo in 1890. Both of these investigators mention that the reflection halo was known and examined before, but they give no references. v. GOTHARD however mentions that ABNEY had found that the cause of the reflection halo was internal total reflection. It is also easy to show that the interpretation of the reflection halo can undoubtedly be traced back much farther than to CORNU and v. GOTHARD.

J. DRECKER,⁴ the computer of the relative intensity distribution of the reflection halo, mentions that the earliest paper where the reflection halo is discussed goes back to about 1865. DRECKER has himself taken this note from a paper in »Liesegang's Almanach» from 1902, where GIOPPI⁵ treats the problem of the reflection halo. GIOPPI declares that C. M. LEA and C. RUSSELL have discovered the cause of the reflection halo.

In four articles in the Photographic News from 1865—70 LEA⁶ investigates the »halation». In the first of them he says concerning the way of preventing »the blurring of tannin pictures»: »It would seem, therefore, every way easier, simpler, and more effective to render the film itself more opaque to chemical rays, and the simplest way of effecting that would be to add some red substance to the collodion — (rosaniline!)».

In the article from 1868 LEA extensively discusses the reflection halo, its explanation as presumed up to that time, and the explanation given by himself. There, however, it will be found that he has not completely succeeded in understanding the phenomenon, because he has not taken account of internal total reflection. The old theory only predicted reflection halo near the edges of the image. It is perhaps not quite right to speak about reflection halo in its true sense, as the term used was »blurring». To eliminate the halo LEA proposes that the emulsion be coloured with red litmus. In the third article he says that backed plates had long been in use.⁽¹⁾ For this backing procedure was used a mixture of Spanish brown, gum and sugar, described by RUSSELL. LEA himself recommends a solution of aniline brown and gum. In the fourth article LEA recommends that the backing be in optical contact with the glass plate.

Prior to these articles there are in fact a number of papers to be found in the Photographic News about halation. The first time when the reflection halo is mentioned seems to be in a communication by G. MARLOW⁷: »Halation, its true cause and remedy», read before »the Photographic Society» on April 2nd 1861. »The object of the writer was to show that the phenomenon, usually known as halation, was the result of the action of light which, having passed through the excited collodion film, was reflected back, and produced the effect referred to. The remedy suggested was the blackening of the back of the plate with black varnish.» In the summary of the published discussion that accompanied the communication it is obvious that no less than four different kinds of halo were distinguished (l. c., p. 158). These are all special forms of reflection or diffusion halos. The difference between these two kinds of halos was obviously known already at that time,

¹ W. MEIDINGER in Handbuch der wiss und angew Photogr, Bd 5 (1932) p. 47.

² CR 110 (1890) p. 551.

³ EDER's Jahrbuch (1890) p. 241.

⁴ Zeitschr f wiss Photogr 1 (1903) p. 183.

⁵ LIESEGANG's Almanach (1902) p. 32.

⁶ Photogr News, 9 (1865) p. 272, 12 (1868) p. 234, 14 (1870) p. 500 and 593.

⁷ Photogr News 5 (1861) p. 164. See also p. 157.

although discussed. For somewhat later, in notes from the readers of the journal the phenomenon called »Halation» was discussed with the editors. (L. c., p. 177).

Some time later MARLOW¹ in a note to the Photographic Society again gives the explanation of the reflection halo. His communication was fully published one year later.²

At the same time a certain Mr ROTHWELL³ also gives the right explanation.

From 1871—72 is found a remarkable investigation by LORD LINDSAY and A. C. RANYARD.⁴ In this the true explanation of the reflection halo is given. The authors also state the difference between the reflection halo and the diffusion halo, and give a method for the elimination of the latter. (See the summary below.)

An interesting but partly wrong explanation of the reflection halo was maintained in 1875 by W. DE W. ABNEY.⁵ He says among other things: — »The most frequently received notion regarding photographic irradiation (i. e. an increase on development of the apparent size of the image of a luminous object when photographed against a darker body) is, that it is due to simple reflection of the incident rays from the back of the plate. This view is quite untenable, excepting in the case where the incident rays fall at an angle with the perpendicular to the surface of the plate.» According to ABNEY the reflection halo should be explained by incident rays which are reflected against the approximately spherical grains of silver halogenids and after penetrating the glass plate reach the emulsion again. He also gives the computation of the intensity distribution in the reflection halo based on his theory. The incorrectness of the theory also makes the mentioned intensity results untenable. The diameter of the reflection halo is however correctly computed by him. At the end of his article ABNEY mentions that he just heard about RANYARD's work, but he supposes it had not been printed. Surely it is the mentioned article by ABNEY that was referred to by v. GOTHARD.

DRECKER (L. c.) is the first to succeed in an exact computation of the relative intensity distribution in the reflection halo.

Lastly, I would like to mention that C. V. L. CHARLIER⁶ in 1889 has given the explanation of the reflection halo and computed its diameter.

And now I give a list of the most important means that have been used or proposed for eliminating the reflection halo, together with the years when they were put forward: —

1861	MARLOW, G.	Black varnish.
1865	LEA, C. M.	Red substance in the collodion.
Before 1868	RUSSELL, C.	Spanish brown, gum and sugar.
1868	LEA, C. M.	Solution of aniline brown and gum.
1871—2	LORD LINDSAY- RANYARD, A. C.	Black varnish or a black, wet paper on the back, or a yellow glass plate.
1875	ABNEY, W. DE W.	1) Covering the back of the plate. 2) Greater opacity of the emulsion. 3) Connecting the silver-halogen particles with a medium of the same optical density as these.

¹ Photogr Soc Journ 7 (1862) p. 150. See also p. 210. ² Photogr News 8 (1864) p. 350. ³ Photogr News 8 (1864) p. 350.

⁴ MN 32 (1871—72) p. 313.

⁵ Phil Mag Ser. 4 Vol. 50 (1875) p. 46.

⁶ Publ der Astr Ges 19 (1889) p. 3.

	4) Staining the collodion itself with an adiactinic colour (compare with C. M. LEA (1865)).
1882 STOLTZE, F. ¹	Aurin collodion with ricinus.
1887	In Photogr. Korresp. No. 313 (1887) p. 113 is proposed a glass plate, dull-polished and blackened, fixed on the glass side of the plate with glycerine between the glasses.
1890 CORNU, A.	Places on the back of the plate a layer of soot stirred in a liquid of the same refraction index as the glass.
1890 v. GOTHARD, E.	Printer's ink was mixed so much with linseed oil that it was possible to coat with a brush.
1891 ¹	In England was used at this time a mixture of asphalt and benzol coated on the back of the plate.
1891 SANDELL, J. ¹	Below the rapid emulsion there was coated a slow emulsion.
1892 ¹	Leaves of gelatine with glycerine were used.
1893 MAGERSTEDT, O. ²	An intermediate layer of gelatine coloured red. Patented as the »Isolar plate».
1903 DRECKER, L.	Colouring the back of the plate. (Among this group of means the manufactures »Solarin», »Antisol», »Rotlack» etc. may be reckoned.)
Before 1909 BARNARD, E. E. ³	Caramel and burnt sienna with alcohol as a dryer.
Before 1931 KING, E. S. ⁴	Thickish caramel.

A reflection halo of peculiar shape. On at least one Helwan plate I found around bright stars a very easily detectable halo which was of a peculiar shape. A description will be given here of the phenomenon, which I classify as a reflection halo.

An image of the halo is shown in Fig. 7, which is an enlargement obtained after reinforcement of the original image by copying it in a suitable way on a diapositive plate. The halo can be roughly described as limited in its interior by a hexagon, with the bright star in the centre. From the central star there run three pairs of diffraction bows of which two pairs are approximately perpendicular to each other — those caused by the two perpendicular rails fixing the flat — and the third pair goes as bissectrice to one of their angles. The diffraction bows will thus not be symmetry-lines to the hexagon. If they are prolonged they end at different places on the sides of the hexagon. In fact, it seems as if the blackening of the halo should lie partly around and partly between the continuations of the diffraction bows. At the corners of the hexagon there are holes in the density. The figure is thus far from being symmetrical.

A common reflection halo gives a circular ring of which the inner edge has a sharp limitation, the radius of which is determined by

$$r = 2d \frac{1}{\sqrt{n^2 - 1}}.$$

¹ SMITH F., Kompendium der Photogr, 14. Aufl. (1922) p. 287.

² Deutsches Reich Patent 73101 (20. IX. 1892) and

77270 (21. IV. 1893).

³ Pop Astr 17 (1909) p. 597.

⁴ A Manual of Celestial Photography (1931) p. 58.

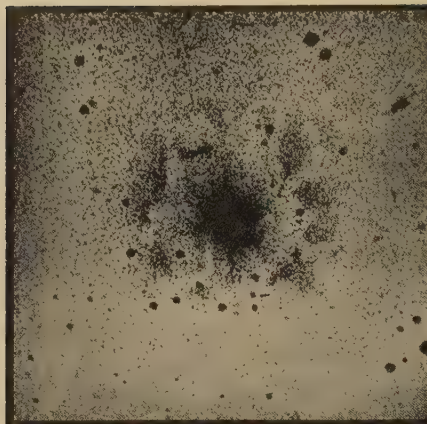


Fig. 7. Reflection halo found on a Helwan plate.

Here d denotes the thickness of the plate and n the refraction index of the glass. For the plate in question d was 1.0 mm. If n is put equal to 1.54, we get $r = 1.7$ mm. This very well answers to the radius of the circle inscribed in the hexagon. The breadth of the halo is about 1 mm and the diffraction bows reach from the central star to about 1 mm from the centre of the star.

An estimation of the distribution of light in the halo may be supposed to be based on a summation of the reflection halos from the central star and the diffraction bows. The intensity in the common reflection halo was calculated by L. DRECKER,¹ but only expressed in per cent of the light sent off from the central point in different directions to the back of the plate. The question of expressing it in per cent of the total light on the central point is still unsolved. Accordingly there is, I think, no chance of performing the computation of the intensities of the complicated halo described here.

On other Helwan plates there are seen no breaks in the halos, also if very strong diffraction bows appear. It must therefore be supposed that quite special conditions may have been prevailing, when the plate was exposed. Perhaps part of its explanation might be based on development conditions. The latter might e. g. have been favourable for strong EBERHARD effects to appear. For an explanation based on development effects we ought however to suspect that the holes in the density should be situated in the prolongations of the diffraction bows, which latter are then supposed to strain the development.

B. THE DIFFUSION HALO.

In many branches of astronomical photography, not only nebular photography, plates of *high speed* and *fine grain* are wanted. The reason is obvious. So for example we want the nebulae, which are relatively faint objects, by the choice of the most suitable brand of plate to reveal as much as possible of their usually very delicate structures. Both properties of the photographic plate, high speed and fine grain, act with regard to anagalactic objects in the direction of a better resolution; the speed in three ways, one connected with the

¹ Zeitschr f wiss Photogr 1 (1903) p. 183.

inconstancy of atmospherical conditions, the second with the observer's care and skilfulness in guiding the instrument, and the third with the direct gain in magnitude caused by the higher speed.

As has often been pointed out, there exists a pull between the two properties mentioned, because it has not been possible to combine high speed with a fine grain. This is still so, although modern plates are successfully made highly sensitive with maintained fine grain. In his well-known work on the physics of the developed photographic image F. Ross¹ points out that the advantage of small size of grain may be overestimated in astronomical photography, because the resolving power of large telescopes even under the most favourable conditions (about 60 μ) lies far below that of emulsions, even of coarse grain and high speed (about 20 μ). Ross also considers it more profitable to work in the direction of attaining higher speed (with unchanged grain size) than attaining smaller grains.

There is a great deal of truth in Ross' considerations. But the gain in sensitiveness of a plate is not always the main thing, and we also have to consider the *gradation* (gamma) of the plate. When using the most sensitive plates, which generally show a weak gradation, there always enter losses in contrast between the object and its background on the plate, or between different parts of the object. In fact, at least for bright nebulae, the photographs appear more beautiful, when a slower and more steeply gradated and fine grain plate is used, than when rapidity is the only factor considered.

For equal rapid plates of the same grain size the gradation can be much different, and we have in fact to consider equally the gamma value of the plate and the grain size. A steeper gradation not only acts increasingly on the resolving power, but also, as will be shown in this paper in detail, makes a considerable increase in the accuracy of determining magnitudes.

Besides sensitivity, gradation and grain size — the most important factors — there are a number of qualities which affect the result of nebular photography and especially the resolution of the objects (the diffusion halo of individual points of the object).

The factors determining the resolving power of a photographic plate may be divided into the following classes:

1) QUALITIES OF THE LIGHT ENTERING.

- a) Intensity.
- b) Colour.
- c) Diameter of cone of rays.

2) PURELY PHOTOGRAPHICAL PROPERTIES OF PLATE.

- a) Spectral sensitiveness.
- b) Total sensitiveness.
- c) Spectral gradation.
- d) Total gradation.

3) GEOMETRICAL QUALITIES OF PLATE.

- a) Absolute size of grains.
- b) Distribution of relative sizes of grain.
- c) Thickness of emulsion.

¹ Kodak Monographs No 5 (1924) p. 153.

4) COLOUR OF EMULSION.

Spectral absorption, especially of dyed plates.

5) DEVELOPER AND DEVELOPMENT CONDITIONS.

6) THE AFTER-TREATMENT.

In the following, for a number of photographic plates used in astronomical photography, there will be given the results of an investigation into some of their mentioned qualities. The work will be presented in three parts.

The qualities of the light entering will be considered, and in necessary cases light of approximately the same spectral constitution as anagalactic objects is dealt with. This also answers to sunlight (spectral type *G0*). Only secondarily other spectral classes are introduced.

The colour of the emulsion might be said to affect the light entering the emulsion. The effect of absorption might be considered as being added to the spectral sensitivity of the plate, and no special regard has been paid to it.

The two last classes above, finally, might naturally be taken together in one group; hence three parts remain, which are investigated here.

* In the first part there will be given speed, spectral sensitiveness and gradation; in the second part the results of the resolving power (in fact related also to the gradation) tested in different ways, grain size and so on; and in the third part the influence of developer, development and the after-treatment.

When making such comparisons, we must keep in mind that the photographic plate is something which is neither kept constant by the manufacturer, nor with this desideration will it be constant, even in one and the same emulsion. Some very useful considerations about this subject were given by A. ODENCRANTS¹ in an extensive paper on photographic photometry, unfortunately published in full only in Swedish. As the cause of observed differences in speed of the same brand of plates he quotes among other things inequality in humidity condensed on the plate. Changes in sensitivity emanating from the same cause (humidity) are discussed by E. S. KING,² P. TEN BRUGGENCATE³ (diminishing of sensitivity) and H. STRASSL⁴ (spectral changes). STRASSL in his paper also mentions similar effects, which were found by SAMPSON. KING also discusses the influence of the temperature and says that it is necessary to distinguish between the effects of temperature and of humidity, as the latter makes the plate less sensitive.

In hypersensitising plates just before using them — at least according to certain methods, e. g. that given by W. DIETERLE,⁵ at which the effect rapidly decreases — we have to pay attention to spectral changes, because the hypersensitizing almost entirely is effective for the long wave-lengths.⁶

If however such a quality as speed of the plate is rather variable, other factors, such as the relative spectral sensitiveness, the gradation and grain size, might be more constant. In the following, therefore, I have with regard to speed preferred not to declare which plate is found to be the most rapid one, but have limited my

¹ Bidrag till frågan om Fotografisk Fotometri (1915). See especially p. 2—4 and p. 26—27. Parts of the subjects of this paper are given again by Prof. ODENCRANTS in Zeitschr f wiss Photogr (1916) and (1917). ² Harvard Ann 59 (1912) p. 63.

³ Boscha Ann Vol 5:1 (1931) p. A 12.

⁴ Zeitschr f Astroph 5 (1932) p. 205.

⁵ Photogr Korr 66 (1930) p. 312.

⁶ J. EGGERT in Agfa Veröff 3 (1933) p. 6.

quotations to spectral comparisons. To decide which plate is generally the most rapid one, many comparisons would be required. For a statistical study, however, which is attempted by me in spite of the fairly scarce material (23 plates in all), also the speed of the plates can be drawn into the discussion.

Sensitiveness and gradation of plates. The spectral sensitiveness and the spectral gradation of the plates were investigated by means of a quartz spectrograph of the big type of R. FUESS, belonging to the Physical Institute at Lund. The distance between the slit and the collimator-objective, and between the camera-objective and the plate-holder was about 40 cm. As light source a calibrated Philips Wolfram spiral filament lamp was used, kindly put at my disposal by Dr. N. RYDE. To obtain characteristic curves for different wave-lengths each plate was exposed for five different intensities of current, giving different intensities of the lamp. In this way five density bands were obtained on the plates, situated parallel to each other and of different blackness. In addition there was exposed in the spectrograph the light from a mercury lamp, the lines of which were to serve for an orientation in the spectrum. Two such series of lines were photographed, placed at both sides of the continuous spectra.

The developer used was a metol-hydroquinone developer of the following tested composition:

- A. Water (warmed) 900 c.cm., Metol 2 grms., Sodium Sulphite (crystals) 80 grms., Hydroquinone 8 grms., Potassium Bromide 2 grms.
- B. Water (warmed) 900 c.cm., Potassium Carbonate 70 grms.

When used, the development solution was mixed in the proportions 1 A + 1 B + 2 Water and the development was carried out in a tank for 10 minutes at 18° C. This time of development is to be considered as of normal length and the penetration of the developer into the emulsion certainly is good. All plates were developed together. The fixation took place in acid hypo for 15 minutes.

The dispersion of the spectrograph for different wave-lengths was determined from a plate on which one iron spectrum and one helium spectrum were exposed.

From the dispersion computed, and by the help of the reference lines on the plates, a series of dots were marked on every plate, at such distances that the wave-length intervals between them were nearly constant (about 150 Å). The photometrical measurement of the plates was carried out with the Moll microphotometer of the Physical Institute at Lund, and was performed at the points marked. The measurement of the photometer papers thus gave the density for bands of a certain breadth on the plate. The density was expressed in the general way as absorbed light, meaning the logarithm of the ratio between the intervals »clear plate to full blackness» and »density in the band to full blackness». The error in a density, arising from the measurement on the photometer paper, is estimated on an average at 4 per cent.

The intensity distribution of the lamp was given by its colour temperature for some different currents. The intensity of the special wave-lengths was obtained by reading from curves, constructed after marking some values of the intensity, computed by the PLANCK formula of radiation.

Consideration was paid to the selective loss of light caused by the prism of the spectrograph and mainly determined by selective reflection at its two boundary surfaces. The selective loss of light between 3000 Å and 7000 Å for the two reflections worked in the same direction and amounted totally to roughly 1.0 per cent.

The effect of a slightly elliptical form of the objective opening as seen from outside the optical axis was found to give even less errors.

As the optical axis of the objective of the spectrograph was directed against the point on the plate which represented about 3000 Å, and as the plate-holder formed a very oblique angle with the direction of the light falling on the plate, there entered with regard to light falling on equal surfaces a loss in red as compared with violet. This selective loss was for the interval mentioned about 1.5 per cent. As it acts in the opposite way as compared with the loss of light in the prism and is of about the same amount, these effects nullify their actions with sufficient accuracy.

Even without this compensation, the amount of both errors falls clearly within the boundaries of the error of the method.

In the computation of the intensity falling on the plate, this was of course reduced from radiation per unit of wave-length to unit of distance on the plate.

Between the density (D) and the intensity of the lamp (i) a characteristic curve is valid for each wave-length

$$D = f(i)$$

The density curves were drawn for the different wave-lengths of which the densities had been measured. These curves formed the material for the following discussion of spectral sensitiveness, total sensitiveness, spectral gradation and total gradation.

Spectral sensitivity. The spectral sensitivity, like the speed of a plate, has in photography been defined in a number of different ways.

Already in 1889 the »Congrès International de Photographie de Paris» decided that the photographic sensitiveness should be considered to be the exposure necessary to produce a definite density (0.350) upon the plate.¹ Unfortunately this excellent definition did not advance, but instead of it the SCHEINER scale and the HURTER and DRIFFIELD scale, as is well known, came to general use.

As a measure of spectral sensitivity G. LEIMBACH² used the incident energy necessary to give a certain density ($D=1.0$, 1.5 and 2.0). Later on L. A. JONES and O. SANDVIK³ and also U. SCHMIESCHEK⁴ used the photographic density which is produced by a constant intensity or constant energy of light for different wave-lengths. During the last few years however the definition has been stabilised to refer to the intensity needed to produce a constant, generally low density for a certain time of exposure. In 1930 H. ARENS and J. EGGERT⁵ referred to the density $D=1.0$ and the time of exposure $t=1$ second, but these writers, like others, also use other definitions. The German DIN-system⁶ is based on a density $D=0.10$ above the veil and a time of exposure of $t=1/20$ second. The commercial methods however only deal with yellow light (sunlight-lamps) or yellow and red light.

From an astronomical point of view there are some special requirements on a definition of sensitivity. Firstly, the *spectral* sensitiveness should be given. Secondly, the time of exposure should be of at least

¹ SHEPPARD S. E. & MEES C. E. K., Investigations on the Theory of the Photographic Process (1907) p. 279.

² Zeitschr f wiss Photogr 7 (1909) p. 205. ³ Journal Opt Soc Amer 12 (1926) p. 401.

⁴ Jahrbuch Luftbildw Versuchsanst Luftfahrt (1930) p. 516. ⁵ Agfa Veröff 1 (1930) p. 26.

⁶ GOLDBERG E. & LUTHER R. in Zeitschr f wiss Photogr 31 (1932) p. 81 and DIN-Mitteilungen 16 (1933) p. 321. See also a paper by M. BILTZ in Agfa Veröff 3 (1933) p. 24 and another by M. BILTZ & E. HEISENBERG on p. 75.

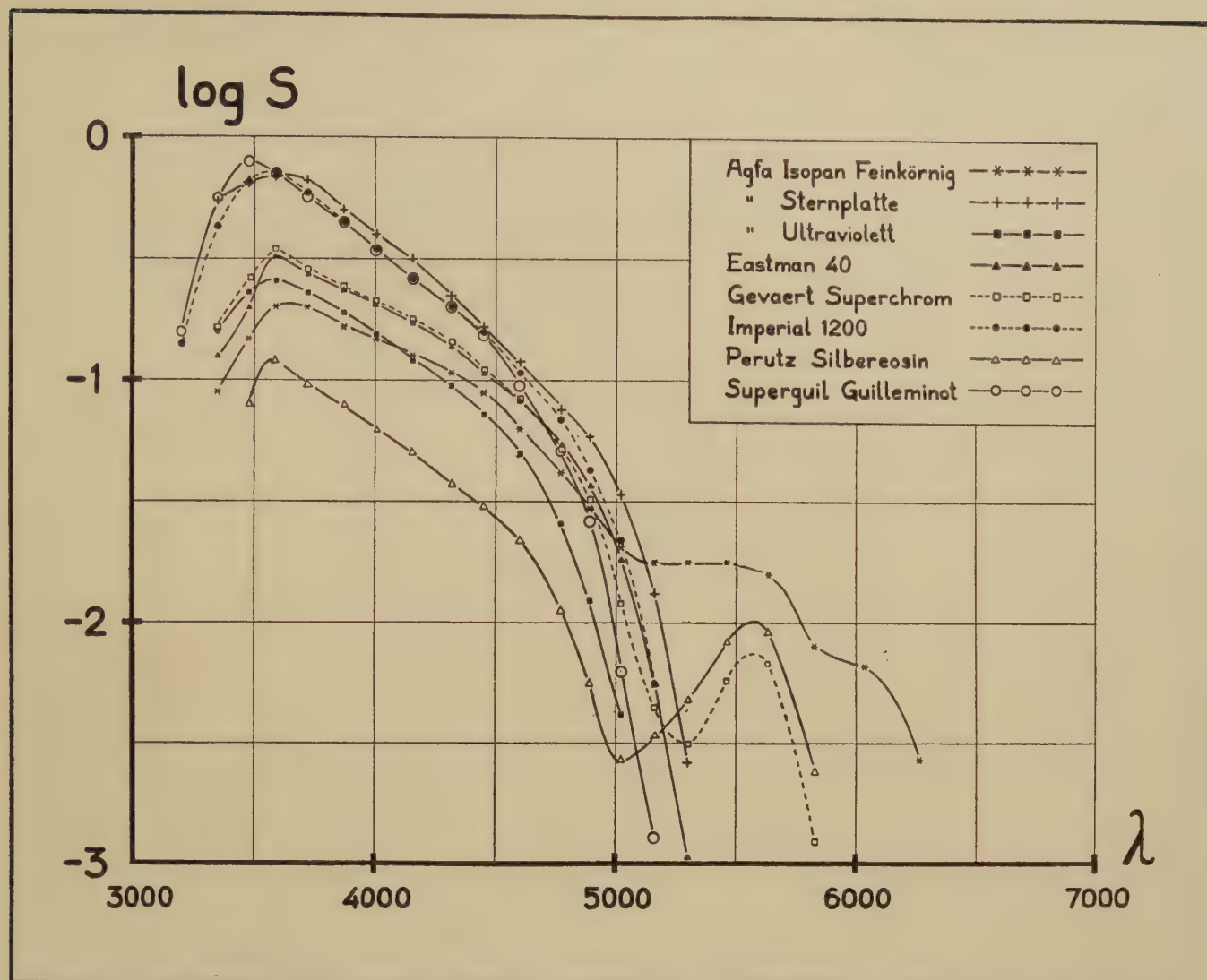


Fig. 8. Spectral sensitivity curves for different brands of plates. The material consists of five ordinary plates: Agfa Sternplatte (crosses), Agfa Ultraviolett (filled squares), Eastman 40 (filled triangles), Imperial 1200 (filled circles, dotted line), Superquil Guilleminot (open circles), two *orthochromatic* plates: Gevaert Superchrom (open squares, dotted line) and Perutz Silbereosin (open triangles); and one *panchromatic* plate: Agfa Isopan Feinkörnig (stars).

approximately the same order of length as the times used in astronomical photography, so that by a comparison of two plates the influence of a somewhat different SCHWARZSCHILD-exponent will not quite change their mutual resulting densities.

The first requirement is fulfilled in the present work except in ultra-violet outside $\lambda = 3200 \text{ \AA}$, where the lamp made use of gave no intensity owing to the fact that it was provided with normal glass. For still shorter waves also the gelatine of the plate absorbs radiation.¹ Of the plates investigated in the present work the Agfa

¹ SCHUMANN V., Wien Sitzungsberichte Bd 102 (1893) p. 415 and 994.

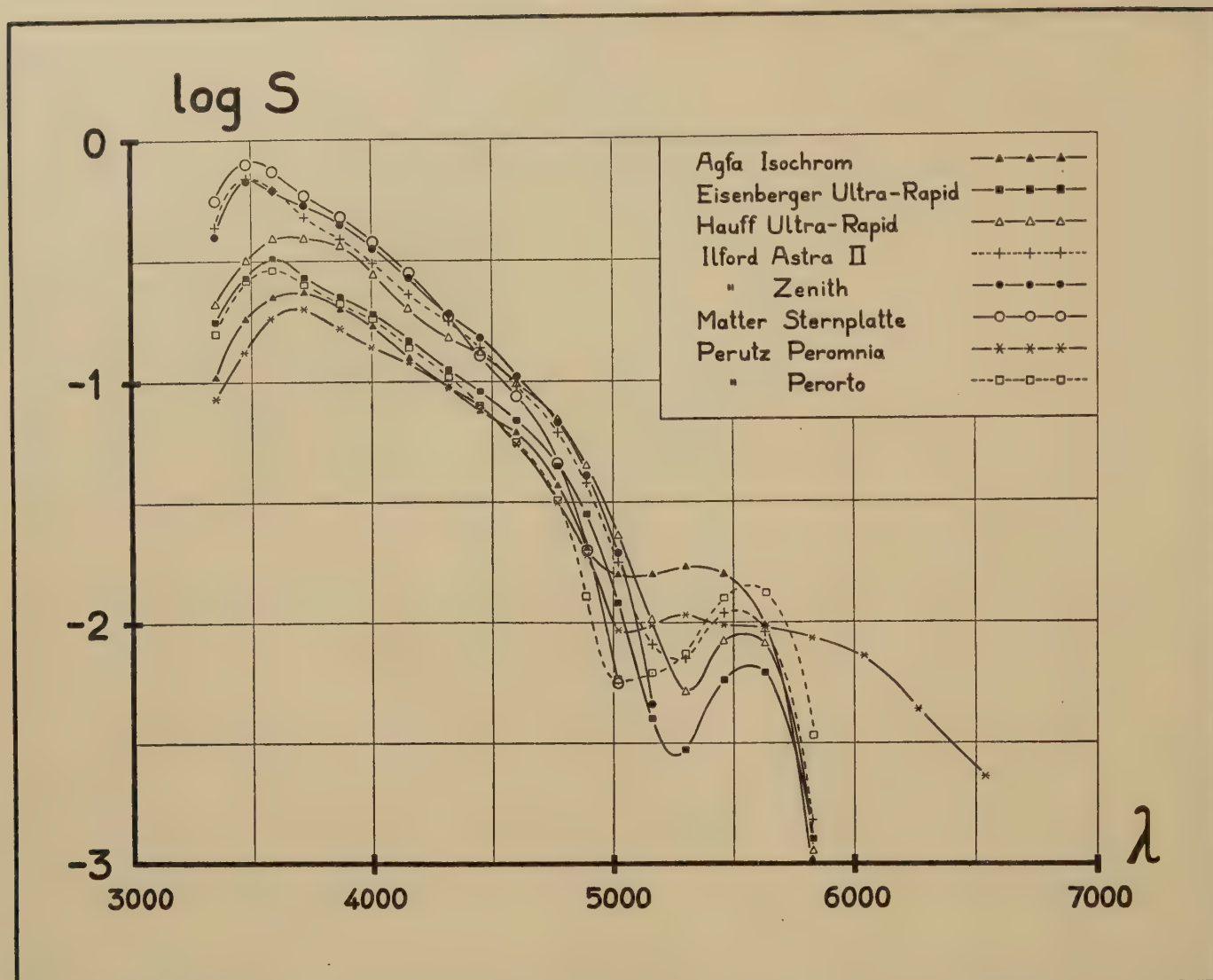


Fig. 9. Spectral sensitivity curves for different brands of plates. The material consists of two *normal* plates: Ilford Zenith (filled circles) and Matter Sternplatte (open circles); five *orthochromatic* plates: Agfa Isochrom (filled triangles), Eisenberger Ultra-Rapid (filled squares), Hauff Ultra-Rapid (open triangles), Ilford Astra II (crosses, dotted line) and Perutz Perorto (open squares, dotted line); and one *panchromatic* plate: Perutz Peromnia (stars).

Ultraviolett plate,¹ which is specially prepared, is suspected to have a considerable sensitiveness also outside 2500 Å.

The second point is approximately settled by using a time of exposure of 30 seconds for 21 of the plates investigated. These times were the longest possible for the intensities of the lamp for which it was calibrated. Further, two special plates, the Ilford Astra I and Ilford Thin Film Panchromatic plates, which were too slow for the mentioned time, were exposed for 2 minutes. For the purpose of nebular photography it had

¹ For this plate see H. ARENS' paper: Spektralphotometrie im kurzwelligen Ultraviolett, Agfa Veröff 3 (1933) p. 19.

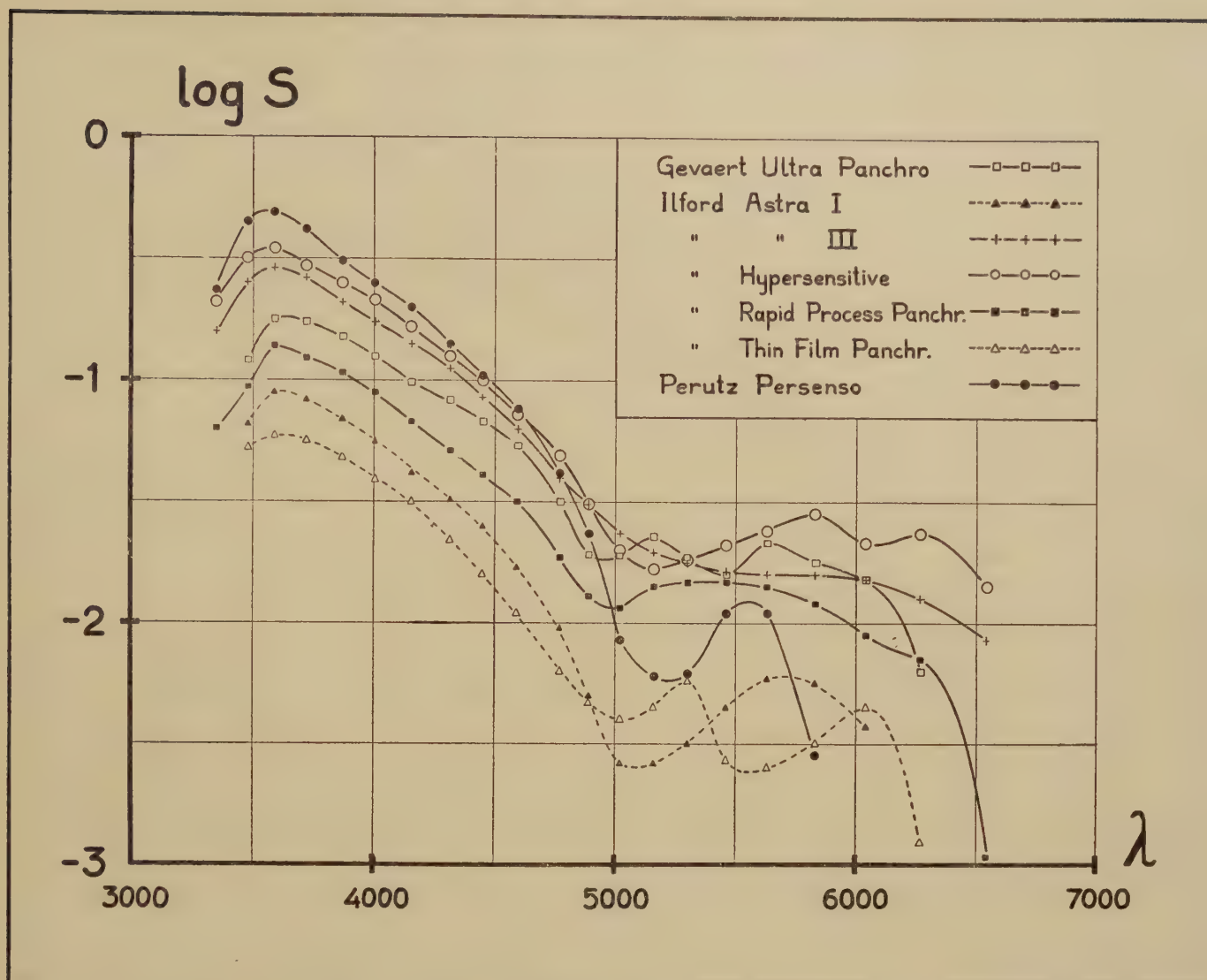


Fig. 10. Spectral sensitivity curves for different brands of plates. The material consists of one *orthochromatic* plate: Perutz Persenso (filled circles); and six *panchromatic* plates: Gevaert Ultra Panchro (open squares), Ilford Astra I (filled triangles, dotted line), Ilford Astra III (crosses), Ilford Hypersensitive Panchromatic (open circles), Ilford Rapid Process Panchromatic (filled squares) and Ilford Thin Film Panchromatic (open triangles, dotted line).

of course been still better if the time of exposure in testing the plates could have been, say half an hour, but in my case this was impossible.

The advantage of a sensitivity definition based on a *constant density* is clear from the following points.

If a series of characteristic curves are crossed by a line representing constant intensity, then the densities corresponding to the points of intersection are determined by a rather unequal accuracy. The accuracy is best by far in the middle portion of the curves, and decreases for low and high densities.

A constant error in the indication of sensitivity will be given if it is based on the intensities which produce a constant density. This means that the series of gradation curves are cut by a line drawn parallel with

the intensity axis. The sensitivity (S) is in this case expressed as the reciprocal of the intensity (i), and this quantity, or more suitable its logarithm, can be put against the corresponding wave-length (λ).

The question arises which density shall be chosen as representing the constant standard density. As a standard must serve a density of such an amount that it is proper for measurements. I have considered $D=0.10$ as quite sufficient, the same density as given in the *DIN*-system. Within nebular photography, such a density is quite satisfactory when regarding measurements or detailed examinations of the objects.

The definition of sensitivity put here in a strict form runs: — The photographic sensitivity in a certain wave-length is the reciprocal of the intensity of light of that wave-length which is required for obtaining a density $D=0.10$ in 30 seconds. Development in metol-hydroquinone according to the formula and development conditions given on p. 49. Apparatus conditions as used here also to be considered.

In reality a complete agreement with other spectral definitions established can never be had, but the run of sensitivity curves according to different definitions will generally be similar for same plates.

The spectral sensitivity curves for the 23 plates tested by me are given in Fig. 8—10. The points marked in the figures denote the measurements, directly obtained from the gradation curves by reading $\log i$ for $D=0.10$. The logarithm of the sensitivity ($\log S$) is given because this means a more suitable scale in the direction of the ordinate axis. (Compare Fig. 11, which gives S directly for some plates.)

In the favourable sensitivity intervals the error of $\log S$ can be estimated at $\delta \log S=0.03$. At the borders of sensitivity of the plates, however, the error increases.

As is expected, many of the curves show a similar run. It is also easy from their spectral sensitivity to divide the plates in groups, commercially named *ordinary* (normal) plates, *orthochromatic* (isochromatic) plates and *panchromatic* plates. In Fig. 8 we find 5 ordinary plates, including the Agfa Ultraviolet plate, two orthochromatic and one panchromatic plate. Two ordinary plates were transferred to Fig. 9, as their sensitivity curves followed those of some other plates very closely, the Matter plate with the Guilleminot Superguil, and the Ilford Zenith plate with the Imperial 1200. The maximum of sensitivity of the ordinary plates is at about $\lambda=3500$ Å, that is in the ultra-violet.

Besides the two orthochromatic plates given in Fig. 8, there are five in Fig. 9 and one in Fig. 10. This type of plate shows two maxima, the greater one at about $\lambda=3500$ Å and the smaller one, giving the orthochromatic character to the plates, at about $\lambda=5500$ Å. The minima occur at about $\lambda=5250$ Å. An exception is formed by the Agfa Isochrom plate, which for this density shows nearly no minimum, but runs approximately parallel with the sensitiveness axis in this region. Thus this plate must be considered as especially favourable for intensities in the region of $\lambda=5000$ Å to $\lambda=5500$ Å.

The panchromatic plates are different from the mentioned two types of plate by having a lower sensitiveness in the short end region of the spectrum and by a sensitiveness extended into the visible red. They show more or less prominent maxima in red at about $\lambda=6000$ Å and less sensitiveness in green (about $\lambda=5000$ Å). The common gap in green is nearly undetectable for the Ilford Astra III plate, which thus, at least for this density, is especially favourable for that spectral region.

A detailed study of the plates, which will best be performed from the curves, shows the range of sensitivity as well as maxima and minima of the curves.

For some of the plates examined here (all plates measured in May 1937), a comparison could be made with results found elsewhere.

So already in 1909 LEIMBACH (l. c.) investigated the plate Perutz Perorto. The general run of the curves is comparable, although the lowest density given by LEIMBACH is $D = 1.0$ and his curves show the maximum at about $\lambda = 4300 \text{ \AA}$.

The plate Eastman 40 has been investigated in 1925 by JONES and SANDVIK¹ who, besides G. HARRISSON,² are the first to show that the maximum sensitivity might occur in the ultra-violet. The spectral sensitivity curves for this plate agree fairly well with regard to maximum and general run. An accurate comparison is difficult to perform owing to different reasons. In fact, JONES and SANDVIK have not taken regard to the failure of the reciprocity law, thus for correcting for this we must know the value of the SCHWARZSCHILD-exponent (p) of their plate. If a p is used less than one (e. g. $p = 0.90$), their sensitivity curve gets flatter. The form then answers well to that of my curve computed for $D = 1.00$, which density is worked with by JONES and SANDVIK. But now the maxima of sensitivity no longer correspond, being so that for my plate the maximum was situated more to the longer waves.

For $D = 0.50$ the maximum of sensitivity occurs at $\lambda = 3850 \text{ \AA}$ and for $D = 1.00$ at about $\lambda = 4000 \text{ \AA}$. There is thus to be noticed that if the sensibility is defined after a low density (e. g. $D = 0.10$), the spectral sensitiveness of the plate can continue to grow against violet when it should decrease after a higher density (e. g. $D = 0.50$).

Besides different density there is another factor to account for in comparing sensitivity of two plates: the developer, which is perhaps the most difficult to correct for in case of unequalities. In our cases a metol(= elon)-developer has been used, but with a constitution and with development conditions which are much different.

There are more plates of the same brands as mine which are also investigated by others, but owing to different definitions, detailed comparisons are only of little interest.

Total sensitivity. The total (or integrated) sensitivity of a plate used to be given by planimetric measurements of the surface contained by the spectral sensitivity curve. But for practical use this means that we presume that the light source to be worked with is of a constant intensity in all wave-lengths. This is, however, the case neither for celestial nor for terrestrial light sources, and the definition is thus inconvenient. Instead of that, we must construct a curve given as the product of the intensity of the light source and the spectral sensitivity curve. For such a manipulation corresponding ordinates have to be multiplied and the products have to be put as new ordinates against the wave-length. Now the surface determined by the curve has to be measured. For astronomical purposes it lies perhaps nearest to hand in this way to determine the total sensitivity for stars of different types, representing light sources of different colour temperatures. For all main spectral types — O, B, A, F, G, K, M — this could be done, but I here only work with the spectral type $G0$, representing approximately the spectral type of anagalactic objects and also of the sun.

The resulting composed curves constructed by me have also been multiplied by the transmission curve of the atmosphere.³ The integrated sensitivities are given in Table 17, where some other data of the plates are also collected.

A special investigation has been carried out for the three types of plate in order to compare the types. Each type has been given by two representative plates:

- (1) Ordinary plates: Guilleminot Superguil and Ilford Zenith,

¹ L. c.

² Journal Opt Soc Amer (1925) p. 341.

³ Values from FOWLE (L. c.).

(2) Orthochromatic plates: Agfa Isochrom and Perutz Perorto,

(3) Panchromatic plates: Ilford Hypersensitive Panchromatic and Ilford Astra III.

For these plates the previously resulting curves have also been multiplied by the squared reflection curve of silver, considering a reflection to be valid when the surface of the mirror is new-silvered.¹ The square enters in counting with two reflections, against the parabolic and the flat mirrors. If we deal with aluminized mirrors, the last multiplications are unneeded, as aluminium shows a nearly constant reflection for all wavelengths in question.

The relative surfaces contained by the curves for these six plates are given in Table 15 and referred to the Superguil plate as unity. In the table are also given the differences in magnitude obtained for the different plates for one and the same source of light and with all factors drawn in computation. The expression calculated was

$$\Delta m = 2.5 \log \frac{\int S' I A R^2 d\lambda}{\int S'' I A R^2 d\lambda}$$

Here S' and S'' denote the spectral sensitivities of the two plates compared; I denotes the spectral intensity of the light source, A the spectral transmission of the atmosphere and R the spectral reflection of a silver mirror. In the computation we enter from integrals to summations of ordinates situated at equal λ -intervals. As the number of ordinates was about 20 this simplification means nearly no error as compared with an exact measurement of the surfaces contained by the sensitivity curves.

The table gives what could be called the *effectivity* of the three main types of plate for a $G0$ -spectrum (anagalaetic objects and the sun). It clearly shows the advantage of ordinary plates over orthochromatic and panchromatic plates.

Table 15. *A comparison of total sensitivity for some plates of the three main types regarding (a) »original» sensitivity; (b) sensitivity for a $G0$ -spectrum photographed through the atmosphere; and (c) a $G0$ -spectrum photographed through the atmosphere and with a reflector having two silvered mirrors.*

Plate	a		b		c	
	Original sensitivity	Loss of magnitude	Sensitivity for a $G0$ -spectrum	Loss of magnitude	Sensitivity for $G0, A$ and R^2	Loss of magnitude
Guilleminot Superguil	1.000	0 ^m 00	1.000	0 ^m 00	1.000	0 ^m 00
Ilford Zenith	0.910	0.10	0.923	0.09	0.973	0.03
Agfa Isochrom	0.370	1.08	0.375	1.06	0.386	1.03
Perutz Perorto	0.422	0.94	0.430	0.92	0.478	0.80
Ilford Hypersensitive	0.559	0.63	0.575	0.60	0.664	0.44
» Astra III	0.462	0.84	0.475	0.81	0.541	0.67

Spectral gradation. In astronomical photography, and especially in nebular photography it is, as was said here and is well known, usually only the lower portion of the density curve that is of actuality. Then it seems natural also to measure the gradation on the lower portion of the curves. In correspondence with this

¹ Values from HAGEN and RUBENS (l. c.).

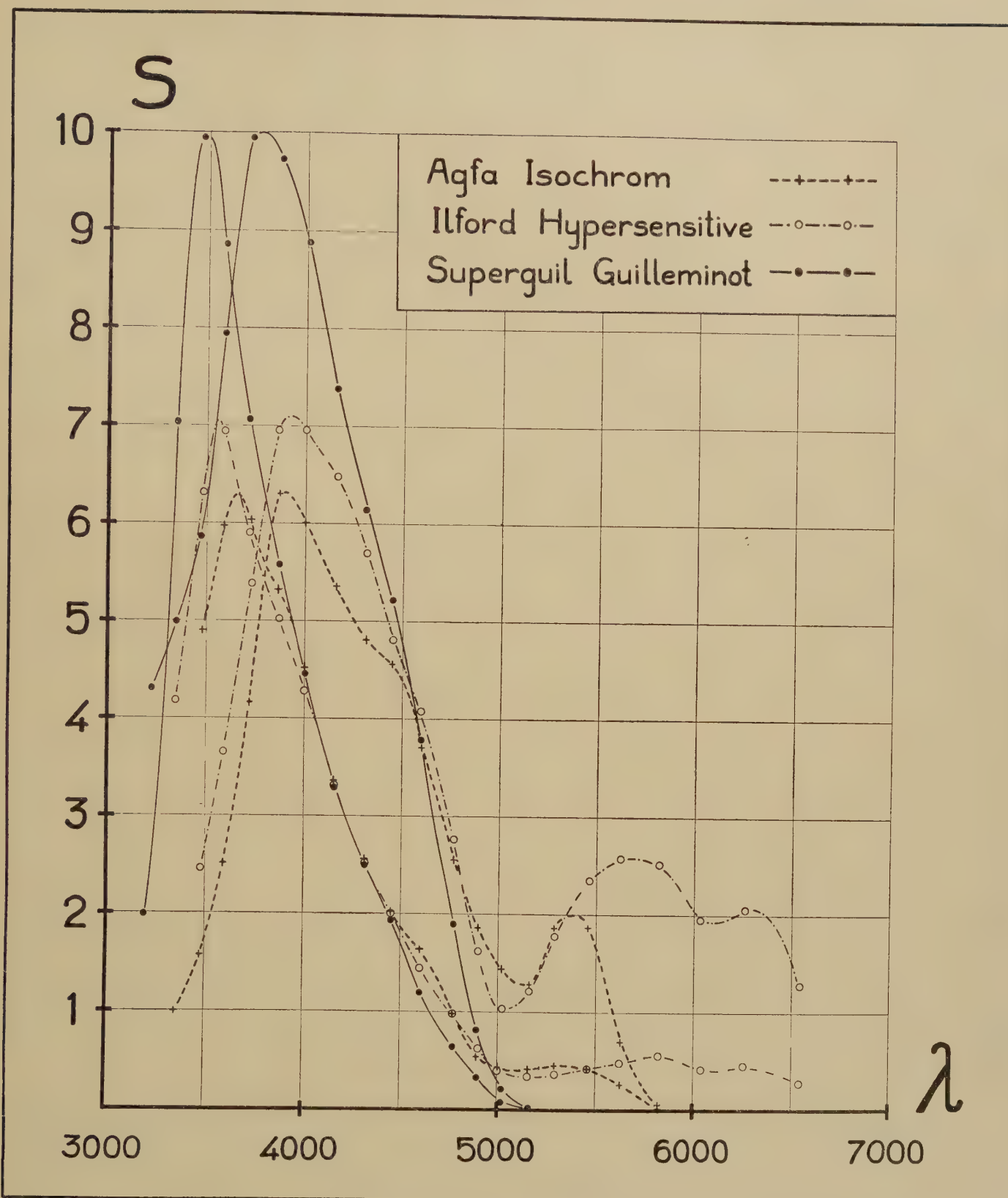


Fig. 11. This diagram is to illustrate how the spectral sensitivity of a plate is changing with the photographic density. Three plates are compared; one normal: Superguil Guillemiot; one orthochromatic: Agfa Isochrom; and one panchromatic plate: Ilford Hypersensitive Panchromatic. The cause of spectral displacement is the variation of gamma with wave-length. Density $D=0.10$ (left curves) and density $D=1.00$ (right curves). The short wave maxima are brought to the same height.

the slope of the line joining the points having $D = 0.10$ and $D = 0.40$ has been measured here. It was easily seen that the gamma obtained in this way appreciably deviates from the gamma obtained from the straight-line portion of the curves, the latter being greater. But it does not deviate so much from the angular coefficient of the tangential line in the point $D = 0.10$, which had been more correct to measure in agreement with the sensitivity definition on $D = 0.10$, but which however was considered to be too uncertain to determine for use here.

In this connection it must be remembered that the plate material was the same as before; the development being the same, as all plates were developed together in a tank. The gradation of course also refers to the metol-hydroquinone developer and to the time of development in question (10 minutes).

The results obtained here and given in Table 16 refer to purely spectral densities. A closer examination of gamma shows that it is not constant, but generally shows a considerable variation of a systematical character. As is well-known the results concerning the dependence of gamma on wave-length, discovered as early as in 1884 by J. M. EDER¹ and in 1889 by A. MIETHE,² have given two directly opposite results; some investigators finding gamma constant, others, and most investigators, finding gamma varying. A review of these questions up to 1915 is given by A. ODENCRANTS.³ Other lists are given by F. ROSS⁴ and F. FORMSTECHER.⁵ From the investigation by JONES and SANDVIK⁶ it is clear that, at least to an appreciable amount, the variation of gamma depends on the development time, a short time giving an approximately constant gamma. For a more diluted developer and longer time of development gamma increases for longer wave-lengths. This fact with necessity also expresses that the constitution of the developer must have influence on the variation of spectral gradation. The action of developer and development conditions certainly explain the discrepancies found. It is of interest to notice that for a special developer, pyro-ammonia, CHAPMAN-JONES⁷ even found that instead of a positive $\frac{\Delta\gamma}{\Delta\lambda}$, which is the rule, a negative value of this ratio was found. To some degree the depth of the image in the gelatine and also the intensity of the light source might affect the result.

According to JONES and SANDVIK an intermediate time of development gives a rather varying spectral gamma curve with one or several minima. The gamma values given in Table 16 also show the appearance of individually varying curves, in agreement with their results for an intermediate time of development (here 10 minutes). The minima in no way answer to the maxima of the spectral sensitivity curves — contrary to a theory proposed by ABNEY⁸ — but correspond fairly well among each other within the three main types. The orthochromatic plates in fact showed two types of curve, one with only one minimum, another with two minima. In his mentioned work, Ross speaks for the opinion that the three types of plate, ordinary, orthochromatic and panchromatic plates, have each one its special curve of variation of gamma with wave-length.

In the table showing gamma, the mean increase of γ with λ , $\left(\frac{\Delta\gamma}{\Delta\lambda}\right)$, is also given, determined in a purely graphical way, without and with consideration taken to spectral sensitivity, and for a λ -interval of 1000 Å as unit. As mean values of the series resulted

¹ J. M. Eder in *Ausführliches Handb der Photogr* 3 (1903) p. 272.

² Diss. Göttingen (1889) (Quoted from Odencrants).

³ L. c., p. 28 and foll.

⁴ L. c., p. 82 and foll.

⁵ *Handbuch der wiss und angew Photographie*, Bd 4 (1930) p. 195.

⁶ L. c., p. 413 etc.

⁷ *Phot Journ* 24 (1900) p. 279.

⁸ *Proc Roy Soc* 68 (1901) p. 300.

$$\overline{\frac{\Delta\gamma}{\Delta\lambda}} = +0.28 \pm 0.02 \qquad \overline{\left(\frac{\Delta\gamma}{\Delta\lambda}\right)}_s = +0.41 \pm 0.04$$

If for an ordinary plate given by Ross⁹ we put gamma against the maximal density of the spectral characteristic curve, we get approximately the straight line $D_{\max} - 2\gamma - 0.8 = 0$.

The relation of maximal density to gamma could not be tested for the present plates owing to their relatively faint densities.

Total gradation. When composed light is used, a gamma must be formed from the spectral gamma with consideration taken to the spectral sensitivity and the spectral intensity of the light source. To get an integrated gamma I have first weighted the spectral gamma with regard to the spectral sensitivity.

$$\bar{\gamma}_s = \frac{\int \gamma S d\lambda}{\int S d\lambda}$$

If in the evaluation we consider that the measured points on the curves in question differ by an approximately constant difference in wave-length, the formula can also be written

$$\bar{\gamma}_s = \frac{\sum_{i=1}^n \gamma_i S_i}{\sum_{i=1}^n S_i}$$

where γ_i and S_i correspond to the wave-length λ_i , and n is about 20.

When also the other functions of λ : the intensity of the light source, the transmission of the atmosphere and the reflection power of the mirrors of the reflector, are drawn into the computation the formula will be

$$\bar{\gamma}_{SIAR^2} = \frac{\int \gamma SIAR^2 d\lambda}{\int SIAR^2 d\lambda}$$

or approximately

$$\bar{\gamma}_{SIAR^2} = \frac{\sum_{i=1}^n \gamma_i S_i I_i A_i R_i^2}{\sum_{i=1}^n S_i I_i A_i R_i^2}$$

where I_i designates the intensity of light, A_i the transmission of the atmosphere and R_i the reflection of silver for the wave-length λ_i .

The results of these procedures together with some intermediate steps are given in Table 16, where as a comparison there are also given the unweighted means of gamma. For I the spectral class $G0$ has been used.

A closer study of the five last columns in the table shows the different mean gamma values computed and their variations. The weighted means grow owing to the fact that by the spectral composition of the light source, the atmosphere and especially the two silvered mirrors, the short end spectrum, which showed the lower gamma, is diminished in action.

⁹ L.c., p. 74.

Table

P l a t e			W a v e -											
No	N a m e	T y p e	3198	3350	3478	3590	3720	3870	4004	4156	4316	4449	4597	
1	Agfa Sternplatte	Ordinary	—	0.32	0.38	0.49	0.51	0.60	0.70	0.79	1.03	1.25	1.36	
2	Agfa Ultraviolett.....	„	—	0.48	0.56	0.67	0.75	0.77	0.77	0.79	0.81	0.88	0.81	
3	Eastman 40	„	—	0.32	0.36	0.36	0.44	0.51	0.55	0.58	0.67	0.77	0.88	
4	Guilleminot Superguil	„	0.25	0.41	0.44	0.57	0.67	0.68	0.81	0.81	0.81	0.81	1.03	
5	Ilford Zenith	„	—	0.43	0.42	0.57	0.64	0.68	0.77	0.86	1.07	1.15	1.50	
6	Imperial 1200	„	0.26	0.41	0.41	0.49	0.57	0.62	0.70	0.79	0.88	1.00	1.20	
7	Matter Sternplatte	„	—	0.53	0.60	0.71	0.86	0.83	0.91	1.00	1.30	1.43	1.43	
8	Agfa Isochrom.....	Orthochromatic	—	—	0.45	0.47	0.52	0.58	0.59	0.62	0.70	0.77	0.88	
9	Eisenberger Ultra-Rapid	„	—	0.44	0.43	0.49	0.57	0.62	0.64	0.67	0.77	0.79	0.91	
10	Gevaert Superchrom	„	—	0.37	0.35	0.39	0.45	0.48	0.50	0.52	0.56	0.64	0.68	
11	Hauff Ultra-Rapid	„	—	0.47	0.43	0.47	0.48	0.51	0.57	0.64	0.72	0.77	0.91	
12	Ilford Astra II.....	„	—	0.41	0.40	0.51	0.62	0.65	0.71	0.86	0.91	1.03	1.15	
13	Perutz Perorto.....	„	—	0.50	0.50	0.59	0.67	0.73	0.68	0.75	0.79	0.91	0.94	
14	Perutz Persenso	„	—	0.39	0.34	0.38	0.43	0.49	0.53	0.57	0.62	0.70	0.75	
15	Perutz Silbereosin	„	—	—	0.33	0.37	0.49	0.57	0.62	0.62	0.64	0.68	0.77	
16	Agfa Isopan Feinkörnig	Panchromatic	—	0.41	0.42	0.39	0.46	0.50	0.52	0.53	0.54	0.60	0.64	
17	Gevaert Ultra-Panchro	„	—	—	0.34	0.37	0.40	0.43	0.45	0.48	0.48	0.54	0.50	
18	Ilford Astra I	„	—	—	0.50	0.51	0.56	0.67	0.71	0.75	0.77	0.83	0.91	
19	Ilford Astra III	„	—	0.54	0.48	0.54	0.60	0.65	0.68	0.70	0.70	0.77	0.79	
20	Ilford Hypersensitive.....	„	—	0.42	0.40	0.46	0.51	0.56	0.57	0.64	0.70	0.75	0.83	
21	Ilford Rapid Process Panchrom.	„	—	0.35	0.45	0.48	0.57	0.61	0.68	0.75	0.86	0.97	0.91	
22	Ilford Thin Film Panchrom. ..	„	—	—	0.70	0.71	0.77	0.86	1.03	0.88	0.91	1.03	1.03	
23	Perutz Peromnia	„	—	0.32	0.39	0.41	0.43	0.52	0.54	0.55	0.58	0.60	0.68	

The resolving power of the plates. The resolving power of a plate is usually tested with the help of some sort of test figure. Different figures, however, are found to give results which systematically deviate. So for example Ross¹ found that a test figure consisting of parallel lines gave a higher resolving power than a fan test object of the MEES type. As the probable explanation is mentioned different conceptions of the figures by the observer. For the same test object two different observers also show systematically deviating measurements.

Besides the two types mentioned here, a fan test object, where bright, narrow lines have been separated by broad dark sectors, has also been made use of in the present tests.

For the reproduction of the test objects on the plates, an ordinary reproduction camera, equipped with a Zeiss Tessar objective of $f = 25$ cm and $F: 4.5$ was used. The quality of the objective thus guarantees that it has a resolving power greatly exceeding that of all common kinds of plate. The focusing of the camera was

¹ L. c., p. 146.

16.

l e n g t h											Slope of gradation		Total gradations				
4770	4891	5020	5159	5298	5461	5632	5827	6040	6265	6542	$\frac{\Delta\gamma}{\Delta\lambda}$	$\left(\frac{\Delta\gamma}{\Delta\lambda}\right)_S$	$\bar{\gamma}$	$\bar{\gamma}_S$	$\bar{\gamma}_{SI}$	$\bar{\gamma}_{SIA}$	$\bar{\gamma}_{SIAR}^2$
1.67	1.25	1.07	0.68	0.56	—	—	—	—	—	—	0.52	0.90	0.84	0.63	0.65	0.67	0.73
0.81	0.77	0.75	—	—	—	—	—	—	—	—	0.18	0.36	0.74	0.71	0.72	0.73	0.75
0.91	0.86	0.70	0.62	0.61	—	—	—	—	—	—	0.29	0.45	0.61	0.52	0.53	0.55	0.58
0.88	0.83	0.75	0.68	—	—	—	—	—	—	—	0.30	0.55	0.70	0.61	0.62	0.64	0.69
1.50	1.43	0.97	0.88	—	—	—	—	—	—	—	0.53	0.80	0.92	0.69	0.71	0.73	0.80
1.30	1.36	0.91	0.86	—	—	—	—	—	—	—	0.48	0.67	0.78	0.60	0.62	0.64	0.70
1.11	1.07	0.75	—	—	—	—	—	—	—	—	0.46	0.73	0.96	0.80	0.82	0.84	0.90
0.86	1.11	0.97	0.91	1.20	1.25	0.81	0.67	—	—	—	0.27	0.36	0.79	0.61	0.62	0.63	0.66
0.88	0.77	0.62	0.73	0.79	0.97	0.97	0.71	—	—	—	0.18	0.34	0.71	0.59	0.61	0.62	0.65
0.70	0.59	0.55	0.59	0.68	0.77	0.75	0.71	—	—	—	0.17	0.23	0.57	0.47	0.48	0.48	0.50
0.94	0.86	0.78	0.65	0.79	0.91	0.95	0.71	—	—	—	0.22	0.25	0.70	0.56	0.57	0.59	0.61
1.11	0.86	0.71	0.65	0.71	0.99	1.00	0.61	—	—	—	0.14	0.59	0.77	0.61	0.63	0.65	0.70
0.81	0.81	0.79	0.77	0.94	1.20	1.36	0.71	—	—	—	0.26	0.32	0.80	0.67	0.68	0.69	0.75
0.70	0.53	0.59	0.58	0.70	0.79	1.03	0.79	—	—	—	0.23	0.24	0.61	0.46	0.47	0.48	0.51
0.79	0.71	0.79	0.83	0.75	1.00	1.15	0.81	—	—	—	0.27	0.31	0.70	0.54	0.55	0.56	0.59
0.64	0.64	0.73	0.86	0.94	1.20	1.25	0.88	0.77	0.70	—	0.26	0.22	0.68	0.52	0.53	0.54	0.56
0.49	0.53	0.62	0.81	0.86	0.86	0.73	1.00	0.79	0.60	—	0.20	0.19	0.59	0.47	0.48	0.48	0.50
0.91	0.91	0.94	0.91	1.03	1.03	1.15	1.36	1.20	—	—	0.30	0.36	0.87	0.67	0.68	0.69	0.72
0.86	0.83	0.94	1.07	1.07	1.20	1.11	1.07	1.25	1.30	0.97	0.27	0.28	0.86	0.66	0.67	0.68	0.71
0.79	0.79	0.73	0.88	1.11	1.03	0.94	0.86	0.86	0.81	0.83	0.23	0.35	0.74	0.57	0.58	0.59	0.61
1.03	1.15	1.11	1.20	1.20	1.11	1.11	1.20	1.15	1.25	1.00	0.25	0.44	0.91	0.68	0.69	0.72	0.77
1.15	1.11	1.00	0.91	1.20	1.11	1.25	1.36	1.43	1.15	—	0.22	0.34	1.03	0.87	0.88	0.89	0.91
0.65	0.56	0.58	0.62	0.71	0.75	0.79	1.03	1.25	1.15	0.91	0.30	0.20	0.67	0.50	0.51	0.53	0.54

made photographically by a series of exposures on the test object, when this was moved step by step along a scale. The distance between objective and plate was thus kept constant after a preliminary visual focusing had been performed. With this arrangement a slow motion screw at the camera back is not needed, since the movements of the object are the same number of times greater than the movements needed at the camera back. The reproductions were made with a diminution of about 10 times. In the focusing the Ilford Thin Film Panchromatic plate, which gave the best resolution of the plates examined by me, but which was also the slowest plate, was used. This plate, together with the Ilford Astra I plate, was included for the interest of special astronomical problems e.g. counting of grains, which is made use of in this paper, but may also be suitable for solar photography etc. The light source was a daylight lamp, which illuminated the test object from behind through a good milk glass. This daylight lamp has approximately the same spectral composition as sunlight, which in its turn has approximately the same spectral composition as anagalactic objects. The objective was put at about $F: 20$, considered to be an aperture giving at least approximately the best sharpness of the instrument.

On every kind of plate there was made a series of exposures of different times, about 10 different exposures with times varying from $1/75$ to $1/2$ second, with the view that that exposure should be found which gave the best possible resolution. The existence of an optimum has no need of explanation, but the range of the optimum was found to be surprisingly high. At least, for a ratio of intensity of 2 or 3 times, it was impossible to detect any change in the optimal region for the method in question. The developer used was the same metol-hydroquinone developer as previously.

The results, which are given as means of two series of measurements performed at different times, are collected in Table 17, where the resolution is expressed in number of lines just detectable as resolved. Only the results of the two fan test objects are given. Those from the parallel lines were not considered so sure, as in this case an interpolation between fairly differing steps had to be done, instead of the measurement of the continuous fan test objects, which was performed with a position micrometer.

The table shows clearly how the plates can be arranged according to resolving power. The figures found here, situated between 30 and 70 lines/mm, agree well with figures found in similar tests made by other investigators for corresponding types of plate. It is very likely that not only the observer's own conception of the figure but also, and perhaps more, the contrast given in the test object — mentioned e. g. by F. KÜSTNER¹ — determines the systematics. It cannot but be suspected that a maximum of contrast in the test object is a goal scarcely possible to attain when constructing the test object and arranging its illumination. As the test objects used here were constructed by photographic reproductions from drawings in black on white, it is necessary that by diffusion the intervening spaces between the black strips on the plates should also be filled with silver grains. A minimum of them is wanted as well as a maximum of silver deposit for the black portions.

The time of exposure in reproducing the test object is known to have influence on the resulting resolution, although its amount is of slight effect. Thus an exponent of a similar kind to the SCHWARZSCHILD-exponent for the density of photographic blackness exists, as the resolving power depends on intensity and exposure time.

Grain size. In the two last columns of Table 17 the mean size of the developed silver grains and their average deviations are given. The measurement of the plates in this respect was made in a microscope with an enlargement of a little more than 700 times, an ocular scale being used. The number of grains measured for each plate was 100, and only the largest diameter was measured. The grains were not situated in the veil of the plate but just at the edge of a heavier density. This was made because we have reason to suspect the grains of the veil being generally larger than the mean grain of the ordinary photographic blackness.

To find out the accuracy of the measurements, these were carried out on two occasions, differing a few weeks in time, and with 50 grains measured on each occasion. The systematical deviation from the first to the second time was $+0.25\ \mu$. The average deviations between the two series were $0.29\ \mu$ before, and $0.21\ \mu$ after correcting for the systematics.

The dispersion of grain sizes given in the last column of the table is the mean of the two series evaluated separately.

Relations of the qualities measured on the plates. Now a number of comparisons were made on the material in Table 17. Graphically they are represented in Fig. 12.

¹ Agfa Veröff 3 (1933) p. 97.

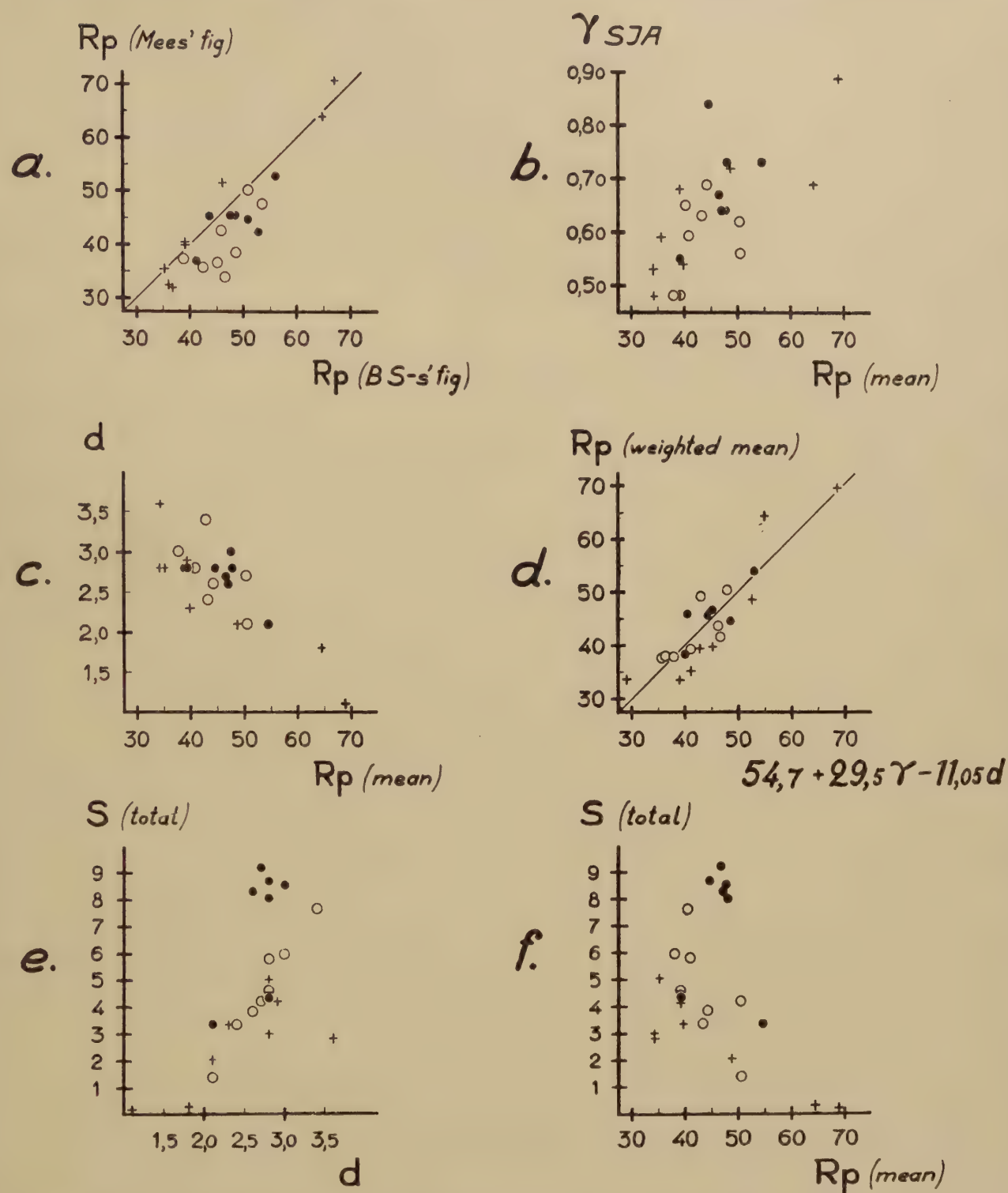


Fig. 12. Relations between some measured qualities of 23 photographic plates made frequent use of in astronomical photography. Ordinary plates are designated by filled circles, orthochromatic plates by open circles and panchromatic plates by crosses.

Table 17.

No	Name of plate	Total sensitivity	Gamma ($\bar{\gamma}_{SIA}$)	Resolving power		Mean grain size ($\bar{d}$)	Average deviation of grain size (Δd)
				MEES' figure	B. S-s' figure		
1	Agfa Isochrom	3.35	0.63	38.5	48.2	2.4	0.71
2	» Isopan Feinkörnig	3.35	0.54	40.5	38.9	2.3	0.59
3	» Sternplatte	9.24	0.67	45.6	47.5	2.7	0.64
4	» Ultraviolett	3.35	0.73	52.8	56.1	2.1	0.56
5	Eastman 40	4.32	0.55	37.1	41.3	2.8	0.98
6	Eisenberger Ultra-Rapid	4.20	0.62	47.3	53.4	2.7	0.68
7	Gevaert Superchrom	4.60	0.48	35.8	42.3	2.8	0.80
8	» Ultra-Panchro	2.83	0.48	32.0	36.7	3.6	0.94
9	Guilleminot Superguil	8.55	0.64	42.4	52.8	3.0	0.71
10	Hauff Ultra-Rapid	5.79	0.59	36.6	45.1	2.8	0.77
11	Ilford Astra I	0.30	0.69	63.8	64.9	1.8	0.49
12	» » II	7.64	0.65	34.0	46.6	3.4	0.88
13	» » III	4.22	0.68	39.8	38.8	2.9	0.66
14	» Hypersensitive Panchromatic ..	5.06	0.59	35.2	35.3	2.8	0.81
15	» Rapid Process Panchromatic ..	2.04	0.72	51.6	45.9	2.1	0.53
16	» Thin Film Panchr. Half Tone	0.22	0.89	70.7	67.0	1.1	0.34
17	» Zenith Super Sensitive	8.04	0.73	44.7	50.8	2.8	0.68
18	Imperial 1200	8.32	0.64	45.5	48.4	2.6	0.84
19	Matter Sternplatte	8.71	0.84	45.4	43.7	2.8	0.70
20	Perutz Peromnia (Braunsiegel)	3.02	0.53	32.3	36.1	2.8	0.84
21	» Perorto	3.84	0.69	42.7	45.7	2.6	0.63
22	» Persenso	5.94	0.48	37.3	38.2	3.0	0.82
23	» Silbereosin	1.39	0.56	50.2	50.7	2.1	0.50

Table 17. A list of 23 plates investigated by the author. Measurements of total sensitivity and gradation, both quantities determined for a light source of a $G0$ -spectrum; resolving power, tested on fan test objects designed by C. E. K. MEES and by the author; and further mean grain size and average deviation of grain size, measured on 100 individual developed silver grains of each plate.

(a) The resolving powers (Rp) according to measurements on the MEES figure and on the B. S-s figure show systematic in favour of the latter figure with

$$\Delta Rp = 3.2 \pm 0.5 \text{ lines/mm}$$

and after correction for this systematic an average deviation of ± 3.6 lines/mm.

The correlation coefficient of the two quantities is found to be

$$r = +0.879 \pm 0.047$$

(b) The resolving power — taken as the mean of the two series — showed an approximately linear relation to the gradation, expressed by the equation

$$Rp - 80\gamma + 6 = 0$$

(c) The relation of resolving power to the grain size, which shows a still less dispersion, is given by

$$Rp + 20d - 98 = 0$$

In these relations, which are found in Fig. 12, Rp is expressed in lines per millimetres and d in thousands of a millimetre (μ).

(d) It is obvious that the resolving power of a plate is dependent on both properties γ and d and that we thus must give Rp in the general form

$$Rp = f(\gamma, d)$$

Remembering that both simple relations are linear we can by using the method of triple correlation¹ find the most probable value of Rp answering to the corresponding values of γ and d .

It is true that the number of individuals is rather small ($n = 23$), but as the relations are very good and thus the mean errors are small I consider it of interest to carry out the computations of a triple correlation. The more I think it is the first time that that method is made use of in this connection.

For the partial coefficients of correlation we obtain

$$\begin{aligned} r_{Rp, \gamma} &= +0.701 \pm 0.106 \\ r_{Rp, d} &= -0.840 \pm 0.061 \\ r_{\gamma, d} &= -0.536 \pm 0.149 \end{aligned}$$

These quantities give the following multiple coefficients of correlation

$$\begin{aligned} R_{Rp, \gamma} &= +0.548 \pm 0.157 \\ R_{Rp, d} &= -0.771 \pm 0.091 \end{aligned}$$

Further the mean values and the dispersions are

$$\begin{aligned} \overline{Rp} &= 44.57 \pm 1.82 & \sigma_{Rp} &= 8.748 \pm 1.290 \\ \overline{\gamma} &= 0.6357 \pm 0.0218 & \sigma_{\gamma} &= 0.1046 \pm 0.0154 \\ \overline{d} &= 2.609 \pm 0.1075 & \sigma_d &= 0.5158 \pm 0.0760 \end{aligned}$$

Then we obtain the final expression

$$Rp = 54.67 + 29.46\gamma - 11.05d$$

¹ C. V. L. CHARLIER in Lund Medd I, 66 (1915).

giving the most probable value of the resolving power of a plate, of which the gradation and the mean grain size are given. In these computations mean values of Rp are used, which were formed by giving the measurements on the MEES figure double the weight of those on the B. S-s figure.

In Fig. 12 d the relation between measured resolving power and resolving power computed from the formula is given. The connection is very close; the correlation coefficient and the average deviation are given by

$$r = +0.888 \pm 0.044 \quad \Delta Rp = \pm 3.33 \pm 0.52 \text{ lines/mm}$$

These values in fact answer to what was found when two series of measurements of resolving power on one and the same plate material were compared.

A computation of the error of Rp from the quantities included in the above relation will give the following result: We can consider the error (average deviation) of observed Rp , γ and d to be: $\delta Rp = 2.0$ lines/mm, $\delta\gamma = 0.02$ and $\delta d = 0.2 \mu$. This gives an average deviation between observed resolving power and resolving power computed according to the formula, ΔRp , which is determined by

$$(\Delta Rp)^2 = (29.5 \delta\gamma)^2 + (11 \delta d)^2 + (\delta Rp)^2$$

The values inserted give $\Delta Rp = \pm 3.0 \pm 0.5$, in excellent agreement with what is actually found, $\Delta Rp = \pm 3.3 \pm 0.5$.

It is well seen here that the most serious errors enter from the measurements of d and Rp , and that the error of γ in comparison with these is almost negligible. If the grain size and the resolving power could be more accurately determined I do not hesitate in believing that the relation between Rp , γ and d would be still more pronounced.

Let us now consider some single plates and see how they are situated in the mentioned relations.

For example the plates Ilford Astra I and III have just the same gradation (0.69 and 0.68 respectively), but differ considerably with regard to grain size (1.8 and 2.9 respectively), as well as to resolving power (64.2 and 39.5 respectively). In the relation between Rp and d (Fig. 12 c) they are both well situated, the high Rp answering to the small d . Here as well as in the combined relation (Fig. 12 d) the Astra I plate has however a resolving power which is somewhat too high. An explanation of the relatively good resolving power of this plate might be that its emulsion is thin, a cause of good resolving power which is well-known, and just a reason of making thin emulsions. The Ilford Thin Film Panchromatic Half Tone plate however has a resolving power which is not extraordinarily high. The explanation to this fact certainly lies in the character of its emulsion, making the photographic film a half tone one (e. g. the concentration of silver-salts in the emulsion). In contradiction to the results generally found for thin films¹ stand certain results by H. KLAUDER and H. SIEDENTOPF,² that thin emulsions of Agfa Astroplatte showed a greater diffusion halo. In fact, it is true that the thinner films of same emulsion show a weaker gradation, and that this should act for a less resolving power, but this might be counteracted if the film reaches a certain tenuity.

¹ See e. g. C. E. K. MEES, Proc Roy Soc 83 A (1909) p. 10.

² AN 256 (1935) p. 178.

Table 18.

Plate Developer	Agfa Isopan Iss		Eisenberger Ultra-Rapid		Guilleminot Superguil		Ilford Astra I		Ilford Hypersensitive		Ilford Zenith	
	B. S-s	A. S-A	B. S-s	A. S-A	B. S-s	A. S-A	B. S-s	A. S-A	B. S-s	A. S-A	B. S-s	A. S-A
Metol	32.9	30.6	38.4	32.9	47.3	41.7	56.9	51.0	35.2	33.5	43.3	43.1
	31.1	31.3	44.2	45.5	40.5	37.6	59.0	48.0	34.6	37.8	44.3	43.6
Hydroquinone	33.1	34.8	36.0	41.2	43.2	40.7	51.7	50.7	35.7	38.3	44.4	38.5
	37.0	31.9	47.6	36.5	51.6	43.2	60.9	47.3	36.6	33.8	46.7	37.8
Metol-hydroquinone	31.7	32.7	42.3	49.0	53.4	40.1	62.0	44.5	33.0	36.9	46.0	36.0
	33.9	32.9	46.2	42.8	45.3	37.0	54.1	46.8	34.5	34.4	45.5	41.4
Parted metol-hydroq.	28.8	29.8	43.5	36.0	43.6	39.3	59.0	46.9	34.3	34.4	44.3	44.3
	31.9	31.9	47.1	40.1	43.9	37.7	55.4	41.9	35.0	38.6	45.3	43.4
Pyro-soda	36.7	31.9	44.1	45.8	41.5	43.0	53.7	49.0	33.9	34.7	43.8	40.2
	35.6	36.6	46.0	45.4	44.2	40.2	59.4	53.0	36.0	39.3	45.3	40.1
Rodinal	43.2	37.3	44.6	44.7	37.0	51.6	48.2	39.3	38.9	34.2	43.3	40.8
	38.9	33.6	47.5	40.9	44.9	41.6	57.1	41.0	36.7	36.9	45.9	42.8
Metol-adurol	40.7	37.2	51.1	56.3	50.6	52.5	55.6	52.2	37.4	37.4	52.4	44.7
	38.9	35.4	56.7	44.3	52.8	44.3	63.0	43.3	42.7	35.3	49.7	39.9

Table 18. The resolving power as tested with a MEES fan test object for a number of photographic plates and for different developers. Measurements performed by A. H. SAMAHA (A. S—A) and B. SVENONTUS (B. S—s).

(e) The relation of total sensitivity to grain size of the plates is given in Fig. 12 e.

There could be expected and it is also found that high sensitivity corresponds to large grains. If we distinguish between the three types of plate, denoted by different signs in the figure, we see how the three types behave somewhat differently. The ordinary plates (filled circles) seem to have nearly the same grain size but show a rather varying sensitivity. The orthochromatic plates (open circles) show a very nice straight line relation of a steep slope. The panchromatic plates (crosses) finally show a slope which is much less steep.

(f) The relation of total sensitivity to resolving power is given in Fig. 12 f. The behaviour of the plates is similar to that in the previous relation, only that here high total sensitivity corresponds to low resolving power, as also is expected. The distribution of points in the Figure 12 f of the three types goes in that way that the slope is also here steepest for ordinary plates, less steep for orthochromatic plates and least steep for panchromatic plates. The linear relations of the two last-mentioned types are especially good.

Resolving power in relation to development conditions. A decided dependence of development on the resolving power of a plate was found by K. HUSE.¹ His tests were made with the MEES fan test object and using Seed Lantern plates. Contrary to him, Ross² found no dependence on the kind of developer. He investigated 16 different developers, and used a yellow-dyed emulsion (Cine Positive emulsion).

¹ Journal Opt Soc Amer 1 (1917) p. 119.

² L. c., p. 149.

Table 19.

Observer \ Plate	Agfa Isopan Iss	Guilleminot Superguil	Eisenberger Ultra-Rapid	Ilford Astra I	Ilford Hypersen- sitive	Ilford Zenith
B. SVENONIUS	35.3	45.2	42.9	55.3	35.5	45.4
	35.3	46.2	47.9	58.4	36.6	46.1
A. H. SAMAHA	33.5	44.1	43.7	47.7	35.6	41.1
	33.4	40.2	42.2	45.9	36.6	41.3
Mean	34.4	44.7	43.3	51.5	35.5	43.2
	34.3	43.2	45.0	52.2	36.6	43.7

Table 19. A comparison of resolving powers as measured by A. H. SAMAHA and B. SVENONIUS.
Means taken for all developers for one and the same plate.

Table 20.

Observer \ Developer	B. S-S	A. S-A	Mean
Metol	42.3	38.8	40.5
	42.3	40.7	41.5
Hydroquinone	40.7	40.7	40.7
	46.8	38.4	42.6
Metol-hydroquinone..	44.7	39.9	42.3
	43.2	39.2	41.2
Parted metol-hydroq.	42.3	38.5	40.4
	43.1	38.9	41.0
Pyro-soda	42.3	40.8	41.5
	44.4	42.4	43.4
Rodinal	42.5	41.3	41.9
	45.2	40.3	42.7
Metol-adurol	48.0	46.7	47.3
	50.6	40.4	45.5

Table 20. A comparison of resolving powers as measured by A. H. SAMAHA and B. SVENONIUS.
Means taken for all plates for one and the same developer.

Both these writers used only one kind of plate, whereas I have entered upon the problem with 6 kinds of plate and 7 developers. The plates were of the following well-known brands: Agfa Isopan Iss, Eisenberger Ultra-Rapid, Guilleminot Superguil, Ilford Astra I, Ilford Hypersensitive Panchromatic and Ilford Zenith Super Sensitive. The developers were: metol developer, hydroquinone developer, metol-hydroquinone developer, parted metol-hydroquinone developer, pyro-soda developer, Rodinal and metol-adurol developer. The formula of

the metol-hydroquinone developer has already been given in this paper; the other developers are to be found in Ilford's formula-book of developers, except the Rodinal of Agfa, and the parted and the metol-adurol developers which were given by Prof. A. ODENCRANTS. The results appear in Tables 18, 19 and 20, where is given the measurements on two quite different series of plates for renewed exposures in the camera and renewed solutions of developers. As before, the results form means of two measurements in the micrometer, performed at somewhat different times. Dr A. H. SAMAHA was kind enough to perform the same measurements as I did and although his experience in this branch is less than mine, I find it useful to compare our results. The systematics existing between our measurements are seen to run in the direction of higher resolving power as measured by the writer.

From the measurements, which can be best followed from the tables, a prominent result can be drawn — the metol-adurol developer gives superior results for all plates investigated. Its constitution, according to Prof. ODENCRANTS, who has been kind enough to let me publish the formula, is:

A. Metol 15 grms., Adurol 40 grms., Sulphite (crystals) 300 grms., Potassium Bromide 15 c.cm. (10 %), Dist. Water up to 3000 c.cm.

B. Soda (crystals) 150 grms., Dist. Water up to 3000 c.cm.

Time of development 30 minutes at 18° C.

The considerable differences found by K. HUSE¹ for resolving power of different developers in maximum conditions are not stated here. But, no doubt, a considerable influence of the developer must exist according to the dependence of Rp on γ and d previously stated here. It must however be said to be specific for the brand of plate, which is also easy to understand from the same point of view. Thus, for every kind of plate there should be chosen a developer which is found to give good resolving power for this plate.

The extremely clear-working metol-adurol developer seems to be superior, regardless of the kind of plate, but of course also here the effect must be specific to different brands of plate. As a rule it seems however to be nearly of the same good action for all of them. An explanation of this general, good action might be that the metol-adurol developer was used as tank-developer (30 min.), whereas the other developers were used for the shorter times (5 to 10 min.) for which they are formulated. Tank-developers are in fact known to give a finer grain but also to give a weaker gradation, which has an opposite effect on resolving power. HUSE, who investigated the action of different developers for different development times, found that its action as an increase or a decrease of Rp is specific to the developer. In this respect the adurol developer has not yet been examined. The penetration of the development solution into the gelatine, the importance of which has been made clear by ODENCRANTS,² is also of great interest in this connection. On this and similar problems I intend to enter in a coming paper on the photographic plate, where also I hope to be able considerably to extend my plate material. Then of course the plate material will not be restricted to plates used in astronomical photography.

¹ Journal Opt Soc Amer 1 (1917) p. 119 etc.

² Bericht über den VIII. Internat. Kongress für Photographie, Dresden 1931 (1931) p. 98.

PART 2. CONTRIBUTIONS TO COLOUR, RESOLUTION AND TOTAL MAGNITUDE OF ANAGALACTIC OBJECTS.

CHAPTER IV.

INFLUENCE OF SPECTRAL GRADATION ON THE DETERMINATION OF COLOUR OF ANAGALACTIC OBJECTS.

There have in the literature been noted some cases where a result of apparently astronomical significance has been due at least partly to the effect of spectral variation of gradation of the photographic plate.

So A. ODENCRANTS¹ in a previously mentioned paper quotes about some early investigations on the selective absorption of light in space: »G. TIKHOFF,² from measurements of SCHWARZSCHILD's constant θ , obtained by stellar spectra, reaches certain results about the absorption of light in space, which are based on the assumption of constancy of the gradation for different γ . The variations of θ obtained were suspected by him to depend on cosmic extinction.

»From a paper by H. H. TURNER³ — the ideas of whom TIKHOFF followed — J. A. PARKHURST⁴ starts an investigation on the same subject, and shows among other things that the gradation — expressed by θ — varies not only with different plates and filtra but also with the density for which it is determined. The results obtained by PARKHURST with the same experimental conditions are contrary to those of TIKHOFF, so the variations obtained by both of them must be attributed to the photographic material rather than to cosmic causes.

»H. E. IVES discusses these questions, and arrives at the conclusion that the question must be left open. The variations of the gradation stated — expressed as variations in the SCHWARZSCHILD-constant — fall within the limits of variation, which, among other investigators, WALLACE and LEMON have stated for equal wavelengths etc.»⁵ —

It is quite clear that in many regions of astronomical photography the effect of selective gradation must be accounted for. In determining colours of anagalactic objects, either we deal with differences in colour for different portions of the objects, or we want to determine a mean colour for the total object, we are highly need of taking regard to the gamma-effect.

In this connection it might be of interest to give the results of a trial to determine differences in colour and total colour indices of some nebulae by the method of exposure ratio (F. H. SEARES'⁶ method), made by

¹ L. c., p. 29. ² CR 148 (1909) p. 266. ³ The Observatory 32 (1909) p. 166. ⁴ ApJ 30 (1909) p. 33.

⁵ Translation by the present writer.

⁶ Mt Wilson Comm 33 and 36 (1916); PASP 27 (1916) p. 123, 191 and 193; and Pop Astr 25 (1917) p. 34.

me in 1934—35 on plates taken by me with the Reynolds reflector at Helwan. On five nebulae, the anagalactic objects NGC 3115, NGC 4594 and NGC 5236, and the galactic objects NGC 1976 (the great Orion-nebula) and NGC 3132 (planetary) extensive series of exposures were made for »blue», »yellow» and »red» images. A number of exposures were also made for the infra-red region. The plates used were Agfa Isochrom, Agfa Superpan and Agfa Infrarot Rapid 730, in connection with suitable yellow and red filters. The times of exposure in a few cases were up to 5 hours. In most cases only one image was photographed on each plate, the plates being however uniformly treated. A comparison of ratios was made with stars of known colour indices, a number of series being taken of different densities.

Two important results were found: the gradations of the yellow and red images of the objects were seen to be generally much steeper than those of the corresponding blue images, and further, the effect was found to depend on the kind of plate and the development conditions. The effect was especially noticeable in studying the diameter law (the increase in diameter with increasing time of exposure) for the objects. The measurements of diameters were made in a position micrometer, and the threads were set on a series of different densities in the nebular images which were estimated by eye. That in this simple way measurements could be had agreeing rather well for different observers, was shown by comparisons of my measurements with those of Prof. LUNDMARK, who was kind enough to measure a series of images on the elliptical object NGC 3115.

The diameter laws found showed much deviation from those of stars on the same plate as the nebulae. The reason is also obvious — in increasing the exposure time, new parts of the nebulae appear. For elliptical objects (e. g. NGC 3115) the increase is undoubtedly very uniform, but for less regular objects it is rather irregular.

But also when using different plates, different diameter laws were obtained. This fact can be interpreted in two ways: (1) either as a real difference in colour between the central and outer portions of the objects, or (2) by a difference in gradation in the various spectral regions in which the photographs were taken. The direction of the effect was that either the central portion was redder, or the gradation was steeper for longer wave-lengths.

A varying spectral gradation was considered possible to play a part already by SEARES,¹ who determined colours of a number of objects of different type. To account for this, when determining colour of stars he thus brought the stellar images to a certain standard diameter. It would be still better if the stars were brought to a certain standard density. For as we have seen, it is the density which determines the effective spectral sensitivity of the plate, and stars of equal diameter are not necessarily of the same density.

With regard to nebulae, SEARES concludes that the centra of certain anagalactic objects photographed by him are very red, and that the faint nebular knots in the spiral arms are extremely blue. Apart from the fact that for the »blue» and »yellow» images he uses different plates, with quite unknown gamma values, even on one and the same plate, with and without filter, there is certainly a change of gradation which cannot be left out of consideration. Supporting the consideration that the colour excess has to be explained much as an effect of the photographic plate is the result by E. P. HUBBLE² that for elliptical objects no differences were found for plates exposed with and without a yellow filter.

¹ Mt Wilson Comm 36 (1916) p. 5 and PASP 27 (1916) p. 126. ² ApJ 71 (1930) p. 231.

We do not need any further discussion of the photographs which are obtained on plates of different kinds. More doubtful and interesting is the question regarding images on the same plate with and without a filter. For this method has also later on come to use by different observers, determining either eventual differences of colour within the objects (e. g. E. F. CARPENTER ¹) or total colour indices of the objects (e. g. E. SCHATTSCHEIDER ²).

Let us for a numerical example of the effect consider the following two plates investigated in Chap. III:

Agfa Isochrom plate.

Ilford Hypersensitive plate.

As filter we assume a yellow filter with the following transmission values given by Schott and Genossen (Germany) in their List No. 4213.

Table 21.

Wave-length (λ)	3120	3340	3660	4050	4360	4800	5090	5460	5780	6440	7000	7750
Transmission in %	1	4	5	12	16	65	99	99	100	100	100	99

Let us consider two points in the nebular object which on the plates without the filter have the densities $D=0.10$ and $D=1.00$. Let us suppose that the low density corresponds to the edge and the high density to the centre of the object. If with the filter the exposure is prolonged until the density of the first mentioned point ($D=0.10$ in the edge) is reached, then for a positive $\frac{\Delta\gamma}{\Delta\lambda}$ the density of the second point (the centre) must be

$$D > 1.00$$

To reach the value of this density, we can proceed with successive approximations in the following way:—

At first we compute the mean gradation between the densities $D=0.10$ and $D=1.00$ for the plate, without and with the filter, and under other prevailing conditions. This computation is quite analogous to the computation of integrated gamma made in Chap. III (p. 59). As spectral type of the object, we assume a $G0$ -spectrum for the centre as well as for the edge.

In our actual case we obtain, including the effect of atmosphere and reflection against two silver mirrors, the following gamma values (Table 22).

Table 22.

P l a t e	Gamma (γ)	
	No filter	With filter
Agfa Isochrom	1.06	1.13
Ilford Hypersensitive	0.93	1.12

¹ PASP 43 (1931) p. 294.

² AN 264 (1937) p. 165.

These values will give the first approximation of the higher densities with filter:

Call the gradation of a certain plate without filter (blue region) γ_b and with filter (yellow or red region) γ_r . Regarding two density curves having these gradations and intersecting at $D = 0.10$, by a simple consideration we obtain the unknown density (D) from the expression

$$D - 1.00 = 0.90 \cdot \gamma_r \left(\frac{1}{\gamma_b} - \frac{1}{\gamma_r} \right)$$

Inserting the values of gamma we obtain:

$$\begin{array}{ll} \text{Agfa Isochrom} & D = 1.06 \\ \text{Ilford Hypersensitive} & D = 1.18 \end{array}$$

By this we have reached the effect of variation of gamma on the density in the first approximation.

For the second approximation we have to determine gamma again but now counted from $D = 0.10$ to $D = 1.06$ and $D = 1.18$ respectively. For this we have to read off $\log i$ from the spectral gradation curves for these higher densities. After that has been done a computation of the gammas gives:

$$\begin{array}{ll} \text{Agfa Isochrom (with filter)} & \gamma = 1.14 \\ \text{Ilford Hypersensitive (with filter)} & \gamma = 1.15 \end{array}$$

Then our equation above gives for the densities in question:

$$\begin{array}{ll} \text{Agfa Isochrom} & D = 1.07 \\ \text{Ilford Hypersensitive} & D = 1.21 \end{array}$$

These are the densities resulting from the second approximation. There is no need of going further. The density exceeds 1.00 in both cases rather much and the excesses are without any difficulty detectable by the naked eye.

To examine to how much it corresponds in apparent difference in colour the following approximate computations are made:

Suppose that the spectral gradation be constant (thus also θ constant), but that a real difference in colour exists between the centre and the edge of the nebula. Denote as follows:

$$\begin{array}{ll} I_{Go} = & \text{spectral intensity in a } G\theta\text{-spectrum (edge of object)} \\ I_x = & \text{» » » the unknown spectrum (centre of object)} \\ S_{0.10} = & \text{» sensitiveness of plate for } D = 0.10, \text{ etc.} \\ A = & \text{selective transmission of atmosphere} \\ R = & \text{» reflection of one of the mirrors} \\ F = & \text{» transmission of filter} \\ t = & \text{the exposure ratio} \\ p = & \text{the SCHWARZSCHILD-exponent (assumed constant)} \end{array}$$

From the difference in density of the two central images we must pass to the ratio of intensity (exposure) for the two same images. If this ratio be c , the equation to be solved is

$$\frac{\int_{\text{Blue}}^{\text{Red}} I_{G0} t^p S_{0.10} A R^2 F d\lambda}{\int_{\text{Blue}} I_{G0} S_{0.10} A R^2 d\lambda} = \frac{1}{c} \frac{\int_{\text{Blue}}^{\text{Red}} I_X t^p S_D A R^2 F d\lambda}{\int_{\text{Blue}} I_X S_{1.00} A R^2 d\lambda}$$

In the equation the only unknown quantity is the spectral class X. The problem thus can be formulated that we have to find the spectral class (or the colour temperature) which brings the two members of the equation equal. Some remarks must however firstly be given regarding some of the quantities entering into the equation.

The value of $c = \frac{I_D}{I_{1.00}}$ will be obtained from the following expression

$$\log I_D - \log I_{1.00} = \frac{D - 1.00}{\gamma}$$

which is founded on a simple consideration on the gradation curve. Putting $\gamma = 1.15$ for our two plates, we obtain:

Agfa Isochrom	$c = 1.15$
Ilford Hypersensitive	$c = 1.52$

According to our assumption p is constant; then also t^p is constant, and this factor, which is common to the two sides of the equation, thus drops out.

According to the previously made assumption on γ , we shall for the sensitivity not use the actual values for the plates found in Chapter III for the densities $D = 0.10$, $D = 1.00$ and the higher density $D > 1.00$, because they are related to each other by a gradation which is varying with λ . As standard of sensitivity we choose the actual sensitivity for $D = 0.10$. If the plate has a constant gradation (γ), the sensitivities for the densities $D = 0.10$ and $D = D$ are related to each other by

$$\log S_D = \log S_{0.10} - \frac{D - 0.10}{\gamma}$$

or expressed in another form

$$S_D = S_{0.10} \cdot 10^{-\frac{D - 0.10}{\gamma}}$$

The special case $D = 1.00$ gives the relation

$$S_{1.00} = S_{0.10} \cdot 10^{-\frac{0.90}{\gamma}}$$

Thus the sensitivities for two different densities now are related to each other only by a constant. Before entering on the numerical computation this constant can be brought out from the integrals.

For the γ entering into the sensitivity we have for both plates to put $\gamma = 1.15$.

The solving of the equation will be done firstly by passing from integrals to summations of products of ordinates separated by equal λ -intervals, and secondly by interpolation or extrapolation after giving I_x for some chosen colour temperatures

$$T < 6150^\circ K$$

It was started with a temperature $T = 4400^\circ K$, or that of an approximate $K0$ -spectrum. The value of T obtained in the first approximation then was used for a renewed computation of a spectral intensity curve according to the PLANCK formula, and a second approximation was made.

In this way for our two plates we obtain the following approximate colour temperatures for the centre of the nebula:

Agfa Isochrom	$T = 4400^\circ K$
Ilford Hypersensitive	$T = 2400^\circ K$

This means that for the Agfa Isochrom plate the spectral change goes from $G0$ to an approximate $K0$. For the Ilford Hypersensitive plate the spectral class of the centre even passes $M0$. The first-mentioned plate is of the type generally used in the SEARES method, and the result obtained with this might be said to be representative.

The values found correspond to colour excesses of about $+0.50$ and $+1.50$ respectively.

These amounts are even in the modest case assumed here — $D = 1.00$ for the greater density — very appreciable and show expressly that it is necessary to account for the influence of spectral gradation. They are in fact probably great enough to explain most differences in colour found. In any case for our Helwan photographs owing to the influence of spectral gradation we do not give any definite values for the objects photographed, as a determination of gamma was not made on the same plate material.

The general rule to be formulated for an influence of spectral gradation in colour determinations is: If $\frac{\Delta\gamma}{\Delta\lambda}$ varies for a plate, and two objects or parts of an object of unequal density but even of equal spectral composition are to be compared, an effect of gamma will enter in the direction of giving the denser image a redder colour if $\frac{\Delta\gamma}{\Delta\lambda} > 0$, but a bluer colour if $\frac{\Delta\gamma}{\Delta\lambda} < 0$. Generally we have $\frac{\Delta\gamma}{\Delta\lambda} > 0$. As is seen in this paper the means suitable to diminish $\frac{\Delta\gamma}{\Delta\lambda}$ is the use of a short time of development; the value is also greatly influenced by the kind of plate.

In addition, we have to mention as another consequence of a gamma variation the case where the images are spread out to small spectra. Also for equal spectral classes, two images which are not of the same density have not their maxima of photographic blackness in corresponding parts of the spectrum. The effect of this must be considered as soon as positions are measured from the maxima or the »centres of gravity» of the density of the photographic images. When determining effective wave-lengths for stars E. HERTZSPRUNG¹ also considers this effect of plate.

¹ Kgl Danske Vid Selsk Skr, Naturv Afd, R 8: 4: 4 (1923).

CHAPTER V.

A PHOTOGRAPHIC CLASSIFICATION OF THE RESOLUTION OF ANAGALACTIC OBJECTS.

Historical notes on the resolution. Already Sir WILLIAM HERSCHEL¹ introduced resolubility as an aid for the description of nebulae to be used together with the qualities size, brightness, roundness and condensation. The symbols used by him are:

er. = easily resolvable,
 r. = resolvable,
 m. = milky.

In his catalogues there are also used such intermediate denotions as

»with difficulty resolvable» (e. g. NGC 4449) and
 »rather milky» (e. g. NGC 5885).

For the classification of resolution introduced by the writer it is also of interest to notice that W. HERSCHEL used such descriptions of nebular structure as

iF. = of an irregular figure,
 C. = Cometic, or resembling a telescopic comet,
 N. = having a nucleus, or bright compressed spot, etc.,

as they in my sense are to be included in a general conception of resolution. Besides »resolution» W. HERSCHEL also speaks about »compression», which means the contrary of resolution.

Sir JOHN HERSCHEL also used resolubility in describing and classifying nebulae, and he made more systematical use of this property. Later on in this paper his classes will be more nearly touched upon.

The classification developed by the two HERSCHELS was on the whole accepted by H. SCHULTZ² at Uppsala, who for the resolubility of »regular nebulae» gives the following five sub-classes:

- a) resolved,
- b) partially resolved,
- c) resolvable,
- d) granulated, or spotted,
- e) milky.

SCHULTZ also explains the meaning of his classes more closely (l. c. p. 21): — So e. g. class 2. (Partially resolved): = resolved part of the nebula quite or nearly free from nebulosity. Class 3 (Resolvable): = single stars steadily visible on nebulous ground, or only momentarily seen glimmering through the nebulosity.

About the last mentioned class he also says: »nebulosity with more or less evident traces of resolubility.»

Of this classification K. LUNDMARK³ says: »The number of subclasses in the above mentioned classification seems to be too small when observing at modern large instruments.»

¹ The Scientific Papers of Sir WILLIAM HERSCHEL Vol. 1 (1912) p. 267.

² Micrometrical observations of 500 Nebulae (1874) and C. A. SCHULTZ-STEINHEIL in Bihang till K Svenska Vet.-Akad. Handlingar 19: 6 (1893).

³ Upsala Medd 30 (1927) p. 20.

An extended number of classes has been used by G. BIGOURDAN,¹ who established a visual classification along the same lines as the HERSCHELs and SCHULTZ, but introduced nine sub-classes of brightness, size, form, condensation and *resolubility*. According to LUNDMARK the classification of BIGOURDAN seems to be excellent for purposes of visual observing.

None of the four observers mentioned have correlated the resolubility with any other quality of the nebulae, but have only made use of it for a purely descriptive classification.

As is well-known, however, already W. HERSCHEL, at least during parts of his life, considered the nebulae as »Island Universes», and in this conception it is clear that he implied a relation to exist between resolution and distance of the objects.

The four classifications above are based on visual observations of the resolubility. With the development of modern nebular photography the possibilities for investigations of the structural properties of anagalactic objects have greatly increased. Some points may be remembered. Lord ROSSE,² the discoverer of the spiral form of nebulae (1845), with his 6-foot reflector discovered visually about 20 nebulae showing spiral form. With I. ROBERTS'³ extensive series of photographs in the years from 1885 to 1904 this number increased to about forty. With J. E. KEELER⁴ a great advancement of nebular photography followed and »a wealth of structural detail was shown impossible to secure visually». He also discovered that a predominantly spiral form was shown to exist in a large proportion of the objects recorded. The study of the structure of anagalactic objects by the modern gigantic reflectors has during the last two decades been the subject of much interest, especially so the resolution into separated stars (LUNDMARK⁵ and HUBBLE⁶).

For the long history and onward to our present understanding of the constitution of anagalactic objects, W. HERSCHEL's theory of nebulae as »Island Universes» has been of great importance. As known, in the cosmogonies of the eighteenth and nineteenth centuries — treated in considerable detail by LUNDMARK⁷ — most nebulae were regarded as composed of stars, but too distant to be seen individually separated. Certain clusters and stellar aggregations which had appeared nebulous with lower powers had in fact been found to be resolvable when higher powers or larger telescopes were employed. A renewed discussion of resolubility will run along the same line, except that we now exclude the different types of *galactic* nebulae. Such an often used classification of anagalactic objects as that of M. WOLF⁸ does not follow a purely resolution line, whereas that of E. HUBBLE⁹ in great does. About his classification WOLF says that it of course is depending on the power of the instrument used, and with greater optical power many objects in the classification pass from one class to another (l. c., p. 109).

A photographic classification of resolution. The anagalactic objects, photographed with any big instrument, are very naturally arranged in a scale according to photographic resolubility. The term »resolution» (resolubility, resolvability) in the sense accepted here may, however, also be considered as meaning »structure» or »detail». We shall here illustrate the meaning of this somewhat.

¹ CR 158 (1914) p. 1949 and Transactions of the Int Astr Union, Vol. 1 (1922) p. 93.

² Phil Trans (1850) p. 499. See also H. SHAPLEY & H. E. HOWARTH, A Source Book in Astronomy (1929) p. 258.

³ A selection of photographs of stars, star-clusters and nebulae. (1893) and Photographs of stars, star-clusters and nebulae. Vol. 2. (1899). ⁴ LICK Publ 8 (1908). ⁵ K Svenska Vet.-Akad. Handlingar 60:8 (1920), and numerous subsequent papers.

⁶ ApJ 63 (1926) p. 236 = Mt Wilson Contr 310 (1926), etc. ⁷ Upsala Medd 30, p. 7 etc.

⁸ Heidelberg Publ 3:5 (1908). ⁹ ApJ 64 (1926) p. 321.

Many outer portions or even nuclei of different kinds of nebulae appear as *resolved*, that is, their photographic images are not homogeneous, but the surfaces are separated into two or more different parts. This can, of course, be caused by an actual spatial difference between parts of the nebulae, or the separation may be only apparent and due to absorption or to parts of less intensity. To be complete, we must in photographic work not only accept as resolved objects where the space between two images is of the same intensity as the background of the plate, but also objects where the intensity is different from this. For in the latter case the intervening space between portions of the nebulae can be produced only by effect of contrast, but it is impossible to decide which.

Analogous to this we can define two kinds of apparent resolution for images on a plate:

- a) that of a first order: a clear separation on the plate between different portions of the nebula and
- b) that of a second order: a structure or density difference of a fairly homogeneous photographic image.

We may say that both kinds of objects show structure, but only objects of the first kind show a real resolution. All forms are to be found, from objects consisting of only two components up to those consisting of a great number, often components exactly like stars. A close connection exists between the resolution class and the number of separated parts.

It is very obvious that the gradation of the photographic plate will influence the result of nebular resolution. A plate of high contrast will act increasingly in the appearance of separation between different parts of an object. On such a plate, however, fainter structures are lost, acting in the opposite direction with regard to resolution. For a plate material emanating from a certain observatory we have no chance of paying regard to possible differences in resolution due to plates of different gradation. For the Helwan plate material, on which this and some of the next chapters are largely based, not only have different kinds of plates been used, but also different developers. For a long time, however, only Ilford Zenith plates were used, and as a developer pyro-soda with time of development 5 minutes at 18° C. Tests made by me with different plates and developments on the same nebulae show that if differences enter, they are only small, and in any case of secondary importance. The greatest influence was shown to prevail in the lowest classes, which is also very natural, as the classification here is partly based on the gradation. A certain relation for these lowest classes thus exists to the *concentration* used e. g. by LUNDMARK¹ and by E. HOLMBERG.² In their cases the gradation of the plate is a source of error of the first order, the concentration increasing with the gamma of the plate.

Other factors which influence the general structure of the objects are the atmospherical halo, the instrumental halo and the photographic halo. The instrument used must of course be referred to, and its focal length and aperture are the essential properties to be given. The exposure time should also be given.

For some of these properties — investigated in Part 1 of this paper — either being not under control of the observer or not available to the author, we must assume average conditions to have been valid. With that presumption we start to investigate the relations of resolution to other apparent properties of the objects. It is very obvious that the apparent size and brightness of the object will be closely related to the resolution. We can also compare the results from different instruments with each other. And there is some

¹ Lund Circ 3 (1931) p. 20.

² Lund Ann 6 (1937) p. 23.

hope that e.g. a detailed comparison of the same galaxy taken by different instruments, or of galaxies in general such as they appear with regard to resolvability when different instruments are used, may contribute to the question of the absolute structure of the objects, the distribution of types of objects, their distances etc. The importance of an estimation of the resolution of nebulae with regard to their physical nature was realized by SCHULTZ.¹ And in fact we need a property of anagalactic objects, which e.g. answers to the importance of the wide difference in colours of stars, a property of which the range with regard to galaxies is very narrow.

The author has standardized here a scale from 0 to 10, where 10 marks the most resolved objects. The denotation for resolution class is R . For example an object of resolution 5.0 is denoted by 5^R0 . A valuable support for my opinion that the scale is continuous and suitable chosen with regard to its grades is given by the fact that Prof. LUNDMARK, whose superior experience on anagalactic objects I have been able to have the benefit of, agrees with me very well in the establishment of the scale. He has independently estimated the resolution of a great number of objects, and there existed no systematics of importance between our estimates. We both consider that commencing resolution ought to be at 3^R0 . What lies below that class is separated by such qualities as distribution of density in the object and deviation from a regular form, and will enter in my second order of resolution. Objects having just zero values will of course very seldom, if ever, appear. As is well-known, even a stellar image will often to some degree show irregularities in its blackening, and is therefore brought up to a resolution of some tenths. Theoretically, however, the class 0^R0 ought to designate the image of a star in perfect focus.

Towards the higher end of the scale, it is perhaps still easier to find out suitable grades on the way up to ten, which is reached by the best resolved objects. All objects above a certain very good standard have been given 10^R0 . Of objects in the Helwan material these are only very few, but with the 60- and 100-inch telescopes of Mt Wilson, of which diapositive plates have been included in a following chapter, fairly many objects reached this point. An asymptote will thus enter here.

With some training it was found very easy to keep the scale unchanged and to perform the classification of the objects.

That the property resolution was fairly easy to be determined was already indicated by a preliminary investigation made in 1935, based on about 100 bright objects on diapositives emanating from the Mt Wilson and the Lick observatories. For this number the average deviation for measurements performed by me and by Prof. LUNDMARK was 0.52 of a scale grade, and the correlation coefficient was about + 0.80. After that we have indeed had so much training and have the scales fixed in our memory. For later estimates in common the deviation has diminished appreciably. The very first values have of course been repeated later on.

Of anagalactic objects in the Helwan zone I give in Plates 1 and 2 a number, chosen approximately to represent every half of the scale, as listed below the pictures. The objects are given in black on white, as they appear on the plates. As known, owing to irradiation there will exist some difference in how the eye will see the superposition of black on white and of white on black.

The comparison between my own and LUNDMARK's estimates of the Helwan objects, catalogued in Appendix III, is shown in Fig. 13. In the case of the latter the estimates of the objects were only carried out once,

¹ Micrometrical observations etc. p. 1.

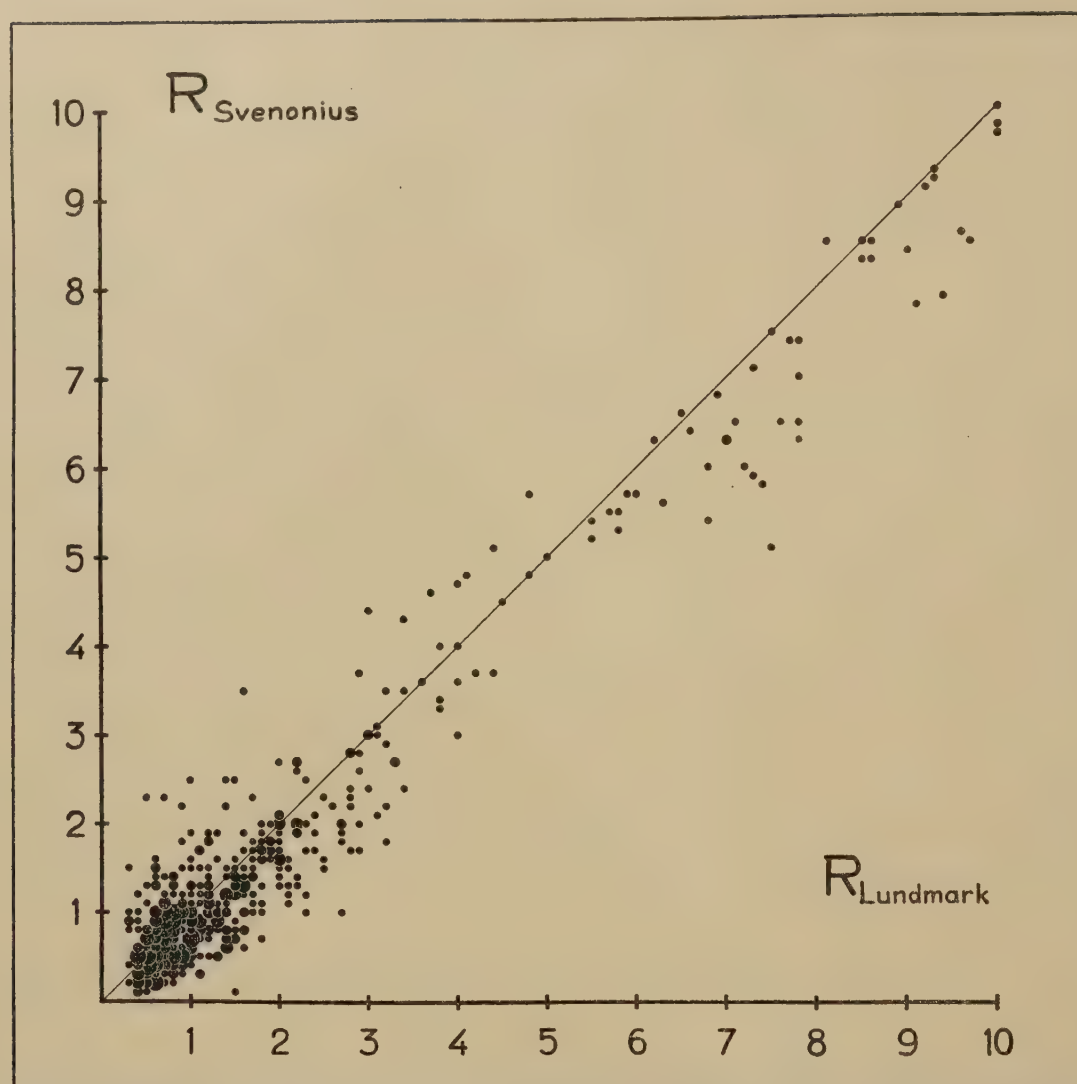


Fig. 13. Comparison between estimates of resolution by K. LUNDMARK and by B. SVENONIUS ($n = 461$).

whereas my own values form averages of two estimates carried out at considerable intervals in time. In the highest classes a systematic exists, giving a lower R according to the author. I have preferred to be a little close in giving the Helwan-objects the highest grades, sparing them for the magnificent pictures obtained with the 60- and 100-inch Mount Wilson instruments. The connection between the estimates performed by me and by LUNDMARK for the present material was very high. The coefficient of correlation and the average deviation between the two series was as follows:

$$r = +0.966 \pm 0.003 \qquad \Delta R = \pm 0.40 \pm 0.14$$

The systematical difference was $R_{KL} - R_{BS} = +0.14 \pm 0.23$.

The corresponding quantities for my estimates of the first and the second time showed similar figures

$$r = +0.971 \pm 0.003 \qquad \Delta R = \pm 0.37 \pm 0.13$$

The systematic between the first and the second series by the author was $+0^m01$, thus practically insignificant. With such estimates from the memory one will be in the highest degree sure that when establishing the scale not a few standard objects will stand as models and cause groupings or discontinuities in the material. In Fig. 13 some groupings still are seen to exist, but in later estimates in common no groupings were found. A factor that is to be paid attention to is that at least approximately the same magnification should be used in the estimates. The magnification used by me was about six times and by Prof. LUNDMARK about eight times. It must also be said here that no difference in our capability to make estimates of resolution was found.

CHAPTER VI.

RELATIONS OF THE PHOTOGRAPHIC RESOLUTION TO SOME OTHER APPARENT PROPERTIES OF THE OBJECTS.

We have reason to expect a decided relation to exist between the resolution of the anagalactic objects and their apparent dimensions or magnitude, because these qualities all vary with the distance in space of the objects. As the objects have by far not the same absolute dimensions or structure, the relations are, however, not a priori to be supposed as simple.

A prolonged exposure or a higher sensitiveness of the plate will increase the dimensions. Besides the increase of the dimensions, the resolution will also increase in general, but not always.

For certain objects, in fact, the different portions will merge together, so that prolonged exposure means diminished resolution. Hence in such cases an optimal time of exposure exists, and it is of course this which is wanted by the observer when photographing. But at the same time as the exposure is prolonged, new outer portions of the object will appear. Because another direction of requirement is to get objects as large as possible, for success along this line the exposure has to be prolonged as much as possible. We can also unhesitatingly suppose that the number of over-exposed objects in a certain plate material is diminutive. A considerable part, however, will consist of under-exposed objects.

Another factor affecting the resolution is the distance from the centre of the plate, for reasons which are considered in Chap. II of the present paper. Of course we cannot limit the research only to objects situated at the very centre, but on the other hand objects too near the edge have not been included. An examination was made of a number of objects situated on one plate in the centre and on another near the edge. For the Helwan plates, for objects of $R > 3^m0$ an approximate decrease of resolution of one or two classes was found, but the amount varies very much with the character of the image of the object.

As example of a nebula showing a typical feature in varying its resolution and dimensions in the sense above, we have NGC 1097, which was already photographed at Helwan by C. C. L. GREGORY,¹ and is described by him as follows: »... spiral with very complicated nucleus which consists of a faint almost stellar centre surrounded by four or possibly five bright patches of nebulosity». A reproduction of the nucleus from a plate of fairly short exposure shows this interesting feature well, whereas nothing is seen on a reproduction of the same object from a plate of longer exposure. From REYNOLDS'² and also from my

¹ Helwan Bull 22 (1921) p. 223.

² MN 85 (1925) p. 1019.

own examinations of objects of the same type, »barred spirals», it seems to be a rule that structures in the nucleus occur.

As to NGC 1097 there is the possibility of locating the disturbance on the nucleus to the small elliptic object, which stands in the prolongation of the bar and very near the main object. On plates of short exposure it shows itself to be nearly as bright as the nucleus of NGC 1097, and probably also its mass is considerable.

Resolution related to dimensions. With regard to a relation of the dimensions to the resolution, it was considered that it is not only the major axis that plays a part. If we consider the galaxies as generally being flat systems, such a system seen edgewise ought to show less resolution than if it were seen perpendicularly to its surface. Thus a function of a and b ought to be used in some form. Here $\log ab$, the logarithm of the surface, was put against the resolution, both quantities as determined by the author. In Appendix III the Helwan objects are listed, as well as the measurements and estimates made on them. The relation between R and $\log ab$ is shown in Fig. 14. Here the three main types of anagalactic objects are given different designations: elliptic objects are denoted by open circles, irregular objects (Magellanic Cloud type) by crossed open circles, and spirals, the greatest group, and all doubtful objects by filled circles. As is seen from the figure, a very pronounced relation exists, being roughly a straight-line one in its main portion. The asymptotical appearance of the curve near the extremes of the resolution is not unexpected. Another marked feature is that the three main types of objects lie systematically to each other. The elliptical objects show a low resolution as compared with spirals of equal surface, and the Magellanic Clouds show a somewhat high resolution as compared with spirals. Whereas the elliptical objects show a position in the diagram separating them well from the other types of objects, this is, however, not the case with the spirals. If in the diagram we place a straight line through the spirals and the Magellanic Clouds, after omitting the lowest surface portion and excluding the elliptical objects, this has the equation

$$\log ab - 0.33 R = 0.70$$

The line was drawn in a purely graphical way. The equation given expresses the relation between resolution and dimensions of anagalactic objects in the Helwan zone, elliptical objects excluded. For the elliptical objects another line is valid, having much less slope with the $\log ab$ -axis.

$$\log ab - 1.0 R = 0.0$$

As the number of elliptical objects in the material is small, the constants of the equation are not very accurate. As given here, the line passes the origin.

The results found indicate that elliptical objects form a group, which is fairly well isolated from the spirals. The Magellanic Clouds also to some extent indicate a group. It is less likely that the different types originate only as a consequence of selection. It would be of interest for a larger material to make a more detailed subdivision according to the different types of anagalactic objects occurring in such schemes as those of M. WOLF, E. HUBBLE or K. LUNDMARK.

As said before, it is likely that the correlation would take regard to the surface and not only to the major axis of the objects. If the resolution is put against the logarithm of the major axis, we find a relation similar to that already given, but a much more pronounced S-form is obtained. The relation between R and $\log ab^2$ was also tried. It appeared to be slightly more rectilinear than that between R and $\log ab$, but the dispersion in the relation was considerably greater.

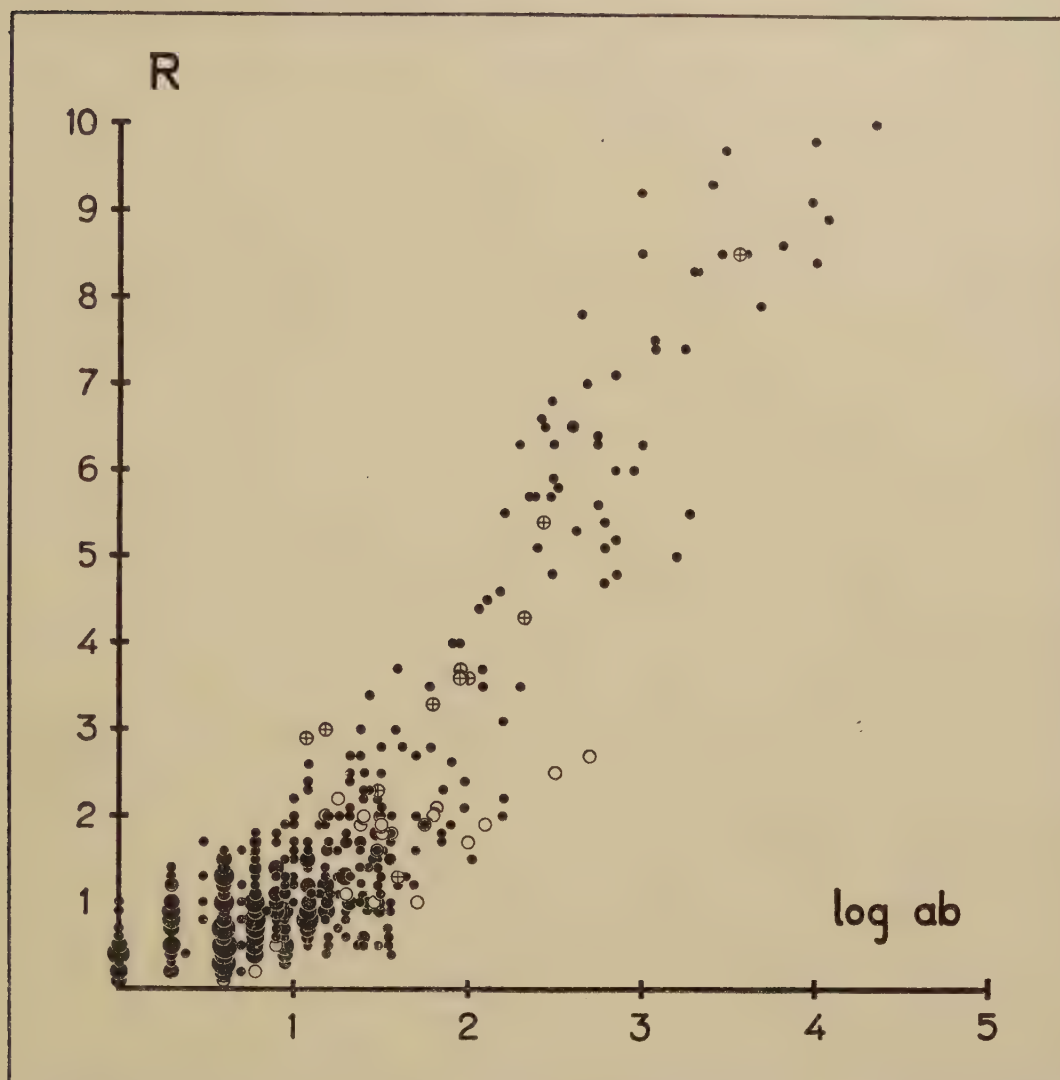


Fig. 14. Relation between resolution (R) and apparent dimensions ($\log ab$) for 461 anagalactic objects photographed with the 30-inch Reynolds reflector of Helwan. Original plates used.

Resolution related to total magnitude. Between the resolution and the apparent magnitude a pronounced correlation is also to be expected. This is evident owing to the high correlations existing between resolution and dimensions and between magnitude and dimensions — correlation coefficients given later on. As is well-known, HUBBLE¹ has given the relation between maximum diameter (d) and total magnitude (m_T) in the form

$$m_T = C - 5 \log d$$

valid for each of his types of nebulae, and where the constants are independent of the instrument used. These two quantities (d and m) are both strongly dependent on the distance of the objects, but in fact the dispersion in the relation is rather high.

¹ ApJ 64 (1926) p. 321.

For the objects photographed at Helwan and described in the Helwan Bulletins,¹ the brightness is given only in the system of letter symbols established by the HERSCHELS. By making use of e.g. the catalogue of SHAPLEY and AMES² for objects down to the thirteenth magnitude, however, an evaluation of these symbols into magnitudes can be performed. This was already done in manuscript by K. LUNDMARK, and it was shown, as could be expected, that these simple estimates of brightness founded on the HERSCHEL system cannot afford any high degree of accuracy.

In spite of this I tested the symbols, putting them into equal intervals against the resolution. A fairly large dispersion over all the field resulted, except near the origin, where all small, faint and unresolved objects gathered.

A by far more pronounced result was obtained by using total magnitudes determined by me.

For determining total (integrated) magnitudes I have used the method developed by K. LUNDMARK³ and frequently used by him, A. AMES⁴, H. SHAPLEY⁵, C. K. SEYFERT⁶ and others. Recently it was used by HOLMBERG⁷, to whom I refer for a nearer description of the method. The star counts for determining the limiting magnitude of the plates were performed by me within 72 or 108 reseau squares dimensioned $5' \times 5'$, which were placed around the object, usually situated at the centre of the plate. The surface of the count thus answered to $\frac{1}{2}$ or $\frac{1}{3}$ of a square degree. According to the brightness and size of the objects of which the integrated magnitude was to be estimated, there have been used either only the limiting star or additional intermediate stars; or a comparison was made between galaxies on the same plate. Every magnitude given in the catalogue forms the mean of two estimates performed at a rather considerable interval of time. Some of the effects entering into a comparison between point objects and surface objects and also between surface objects of different forms have been treated in a later chapter (Chap. X, p. 116). If the gradation of a plate is unknown, it is necessary that at the determination of total magnitudes only densities of the same blackness should be compared. A knowledge of the gradation of the plate can, however, be obtained by star counts on a series of stars of different brightness. But the labour involved is rather great, and the method probably requires considerable experience by the observer to give good results. To some extent, however, it was used by me, and found to work satisfactorily.

The total magnitudes obtained by me were compared with the brightnesses as determined at Helwan. The latter show to consist of a mixture of total magnitudes and surface magnitudes, with a decided inclination to the last mentioned type.

For the objects in common with the SHAPLEY-AMES catalogue of bright galaxies a comparison was made. As shown in Fig. 15 no very great systematics seem to exist between the two series of magnitudes except for the brightest objects, of which also the estimate was considered uncertain or even very uncertain. The mean difference in magnitude for the 55 objects in common with the mentioned catalogue amounted to

$$m_{\text{Shapley-Ames}} - m_{\text{Svenonius}} = -0^m06 \pm 0^m05 \quad (n = 55)$$

On my request another determination of magnitudes from the same Helwan plates was done by Dr. A. H. SAMAHA. The magnitudes of Dr. SAMAHA are given together with mine in Appendix III. I am thankful for the

¹ Helwan Bull 9 (1913), 15 (1914), 21 (1921), 22 (1921), 30 (1924) and 38 (1934).

² Harvard Ann 88:2 (1932) p. 43.

³ Lund General Catalogue of anagalactic objects (unpublished). Upsala Medd 21 (1927) etc.

⁴ Harvard Circ 257 (1923) etc.

⁵ Harvard Circ 294 (1926) etc.

⁶ A copy of an extensive unpublished paper containing total magnitudes of more than

7000 objects has kindly been placed at my disposal by Prof. LUNDMARK.

⁷ Lund Ann 6 (1937) p. 25.

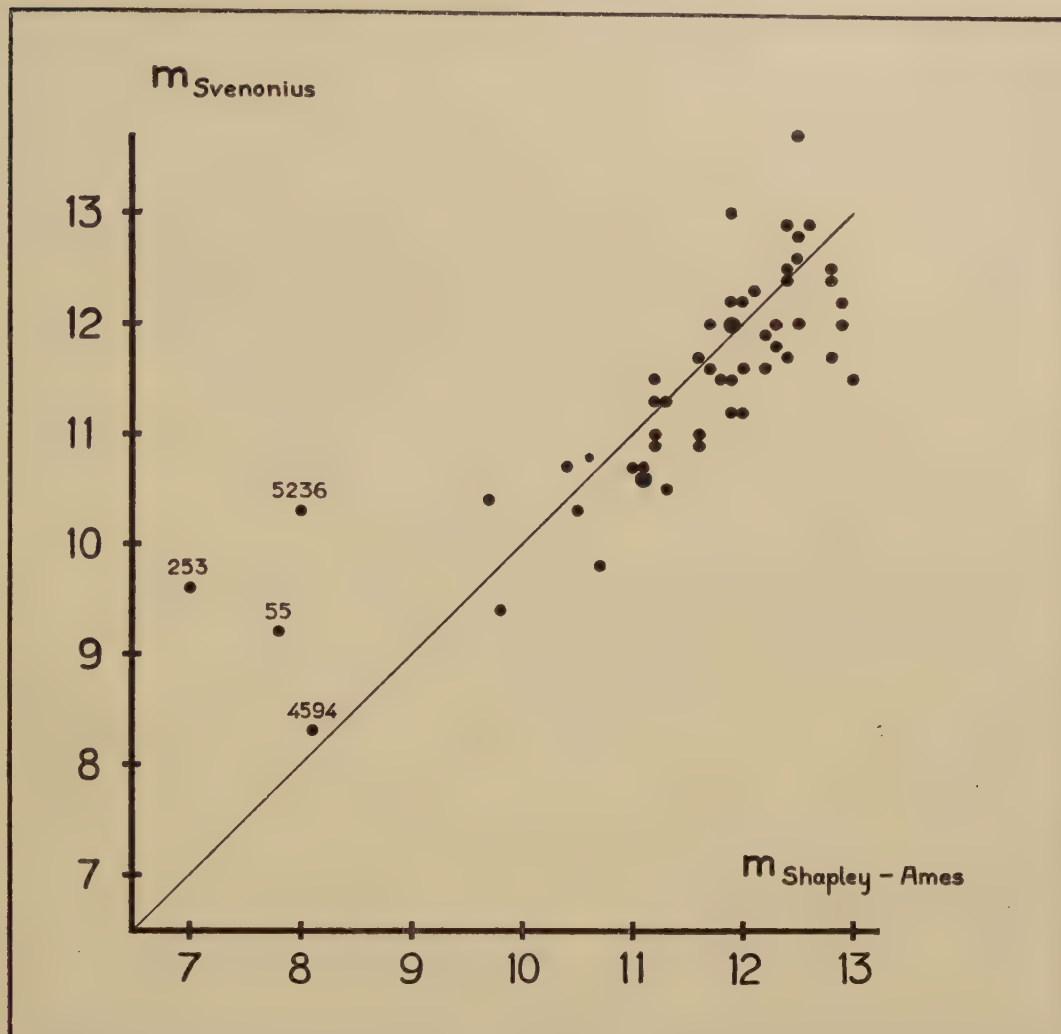


Fig. 15. Relation between B. SVENONIUS' integrated magnitudes for 55 Helwan objects and the corresponding SHAPLEY-AMES' magnitudes.

opportunity to compare our results. The relation between our magnitudes is seen in Fig. 16. The correlation coefficient has the value

$$r = +0.909 \pm 0.008$$

Systematics existed for the brighter magnitudes, whereas the fainter magnitudes agreed fairly well. The mean difference is

$$\overline{m_{\text{Samaha}} - m_{\text{Svenonius}}} = +0^m.23 \pm 0^m.03 \quad (n = 454)$$

As was seen before, my bright magnitudes showed in fact no systematics to the SHAPLEY-AMES catalogue. The dispersion in the magnitudes, given as the average deviation between our series was $0^m.49$.

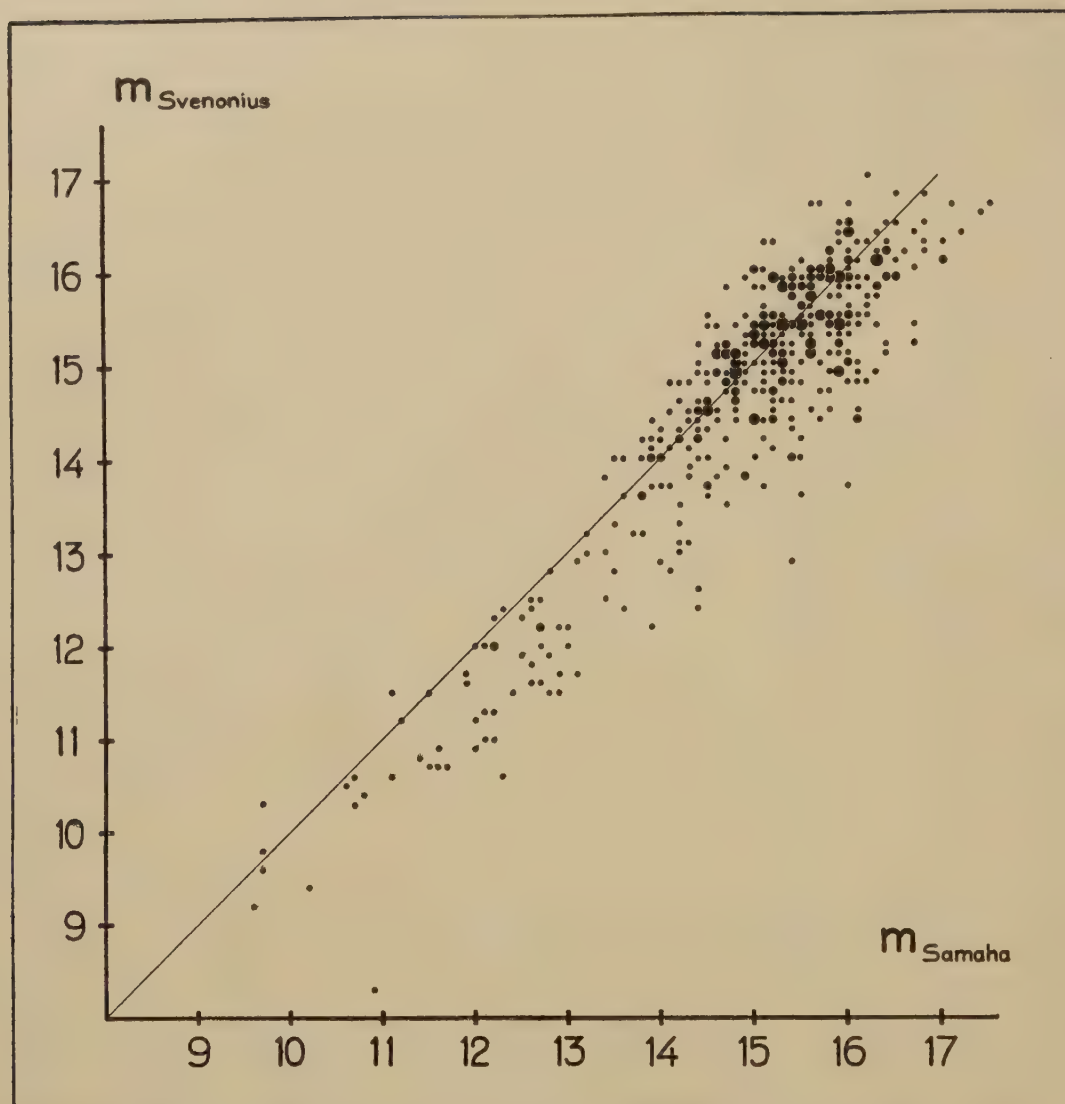


Fig. 16. Relation between A. H. SAMAHA's and B. SVENONIUS' integrated magnitudes for 454 Helwan objects.

The connection between the integrated magnitude and the resolution of the objects is given by Fig. 17. As is seen in this figure, a bright magnitude answers to high resolution and conversely. The three main types of anagalactic object are denoted by different designations, and, as before, elliptical objects are marked by open circles, Magellanic Clouds by crossed circles, and spirals and doubtful objects by filled circles. A corresponding layering is found here as compared with the connection between R and $\log ab$. After excluding elliptic objects and objects fainter than about $16^m.0$ a straight line was placed and found to have the equation

$$m + 0.60 R = 15.6$$

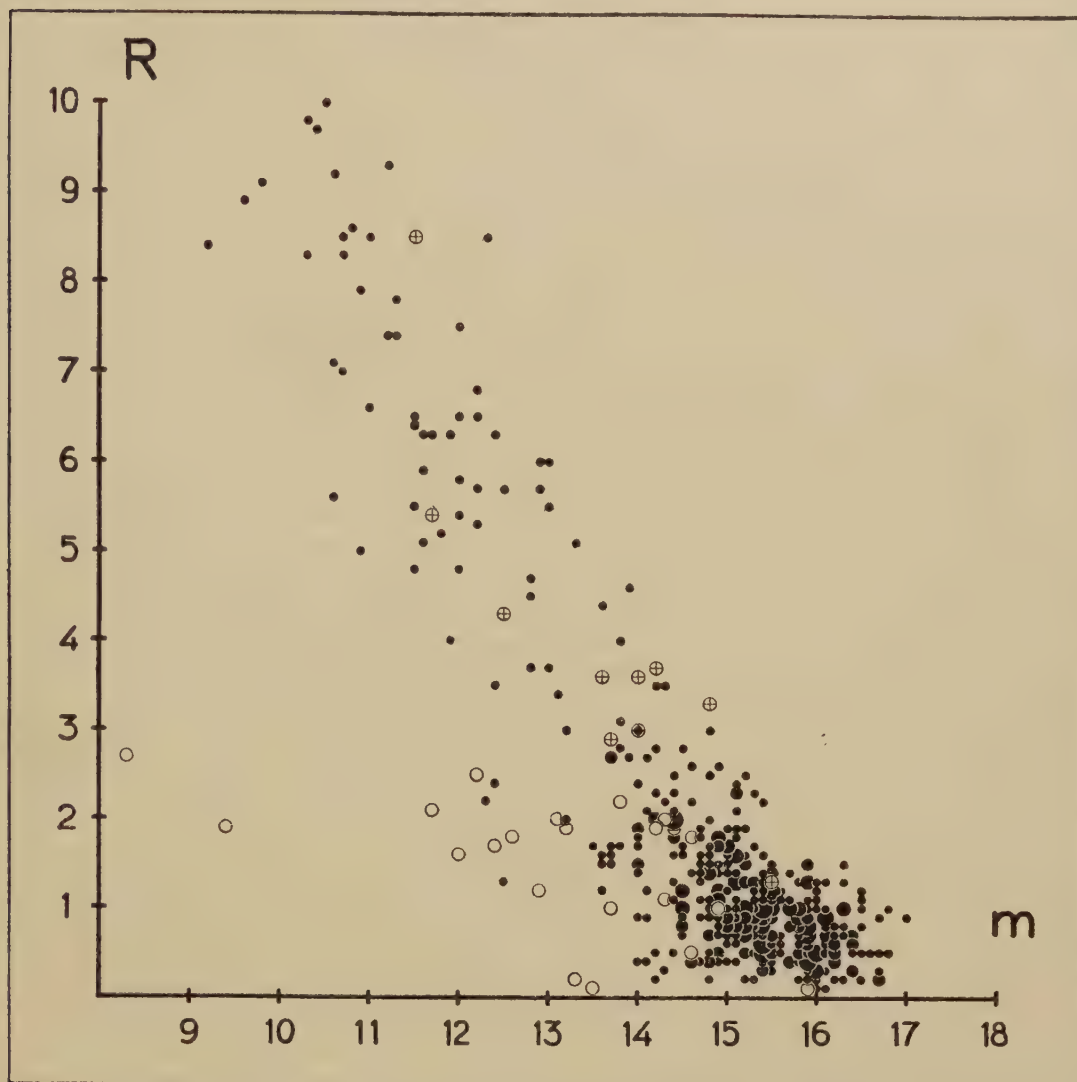


Fig. 17. Relation between resolution (R) and total magnitude for 461 anagalactic objects photographed with the 30-inch Reynolds reflector of Helwan. Original plates used.

The line can be said to give the mean magnitude of an object (elliptic objects excluded) which is required to show the object resolved to a certain degree by the 30-inch Reynolds reflector under average conditions.

A line placed through the few elliptic objects has a slope much less inclined to the m -axis. Its approximate equation is

$$m + 5 R = 20.5$$

Lastly the mean values of R as found by LUNDMARK and by the author were put against the mean values of m as found by SAMAHA and by the author. The relation found for this material agreed very well with the previous result.

It was found

$$m - 0.56 R = 15.8.$$

Resolution related to dimensions and total magnitude. Now I am going to show the resolution put in relation at the same time to both properties investigated, dimensions and total magnitude. For this a triple correlation was carried out. Objects classified as elliptical were excluded in advance. Consequently after this we are dealing only with the common spiral series, the few Magellanic Clouds included. The elliptical objects are in fact expected also in the combined relation to deviate much from the main branch, since in both single relations they lie low with regard to resolution. Also for the Magellanic Clouds we could expect a systematical deviation, but as they differ very slightly, if at all, we prefer to include them.

For the 436 objects brought into the computation we find the partial correlation coefficients

$$r_{R, \log ab} = + 0.891 \pm 0.010$$

$$r_{R, m} = - 0.890 \pm 0.010$$

$$r_{\log ab, m} = - 0.854 \pm 0.013$$

These give the multiple coefficients of correlation

$$R_{R, \log ab} = + 0.553 \pm 0.033$$

$$R_{R, m} = - 0.547 \pm 0.034$$

For the mean values and the dispersions of the three quantities we get

$$\bar{R} = 1^{\text{R}}874 \pm 0^{\text{R}}099 \qquad \sigma_R = 2^{\text{R}}060 \pm 0^{\text{R}}070$$

$$\bar{\log ab} = 1.259 \pm 0.039 \qquad \sigma_{\log ab} = 0.807 \pm 0.027$$

$$\bar{m} = 14^{\text{m}}693 \pm 0^{\text{m}}071 \qquad \sigma_m = 1^{\text{m}}478 \pm 0^{\text{m}}050$$

Finally, making use of these quantities we get the most probable value of R , given by

$$R = 1.235 \log ab - 0.664 m + 10.063$$

If we compare the resolution estimated with that computed from the right hand side of the expression here, we find a high correlation. The coefficient of correlation and the average deviation amounted to

$$r = + 0.924 \pm 0.007 \quad \Delta R = \pm 0^{\text{R}}62 \pm 0^{\text{R}}02$$

Even if the relation between R , $\log ab$ and m were accurately valid, we have no reason to expect a higher correlation coefficient to be obtained, owing to the great errors in the determination of the quantities mentioned. With the errors found in the present paper for R , $\log ab$ and m (about $0^{\text{R}}4$, 0.2 and $0^{\text{m}}3$ respectively) we get in fact an average deviation between observed and computed R of the order of size $\Delta R = \pm 0^{\text{R}}5$ instead of $\Delta R = \pm 0^{\text{R}}62$ actually found.

CHAPTER VII.

A COMPARISON OF ORIGINAL PLATES AND DIAPOSITIVES REGARDING DIMENSIONS, TOTAL MAGNITUDE AND RESOLUTION OF ANAGALACTIC OBJECTS.

For different kinds of measurement of nebulae original plates should if possible be used, because in copying changes of gradation might take place and details be lost. But if only diapositives (or possibly paper copies) are to be had, they can of course be used with advantage for special investigations. So for example the general character of the objects can be seen, the elongation as well as the direction of the axes can be measured, positions also can be measured etc. Further, as has been shown by C. G. DANVER¹ in an investigation on the spiral form of anagalactic objects reported on at the »A. G. Kongress» in Breslau 1937, good diapositives can be as useful as originals for a study of the mathematical form of the spiral arms.

For dimensions, magnitudes and structural properties of nebulae, the change of gradation and the loss of detail, however, must be suspected to play a part. How great the part is of course depends on the quality of the diapositive. In the following I give some results obtained by comparisons of a number of original Helwan plates with what I should call good diapositives of them. Reproductions were made of 50 plates by contact copying. Agfa Kontrast plates were used if the original was not very dense, in which latter case Agfa Normal plates were used. The development was performed in the metol-hydroquinone developer mentioned on p.49, but in the concentration 1A + 1B + 1 Water. Development time was about 5 minutes at 18°C.

To obtain the same difference of density between two points in the image of the diapositive as exists on the original plate, the gradation curve of the diapositive plate must have a gamma equal to unity. The measurement of gamma for the mentioned two kinds of plate gave:

Agfa Kontrast plate: $\gamma \sim 2.0$. Density interval 0.20—1.00
 » Normal » $\gamma \sim 1.0$. » » 0.20—1.20,

a time scale being used.

On the diapositives there were determined the limiting magnitude of the plates by star counts, and further the dimensions, integrated magnitude and resolution of the objects.

Limiting magnitude. Some loss of limiting magnitude is unavoidable in the copying of a plate. The mean value of the loss measured on 50 plates amounted to

$$m_{\text{orig}} - m_{\text{diapos}} = + 0^m.26 \pm 0^m.06 \ (n = 50)$$

It was considered of some interest to see if the loss of magnitude were dependent on the limiting magnitude of the original plates. Therefore the differences in magnitude ($m_{\text{orig}} - m_{\text{diapos}}$) were put

¹ A preliminary note has appeared in Lund Medd I, 147 (1937).

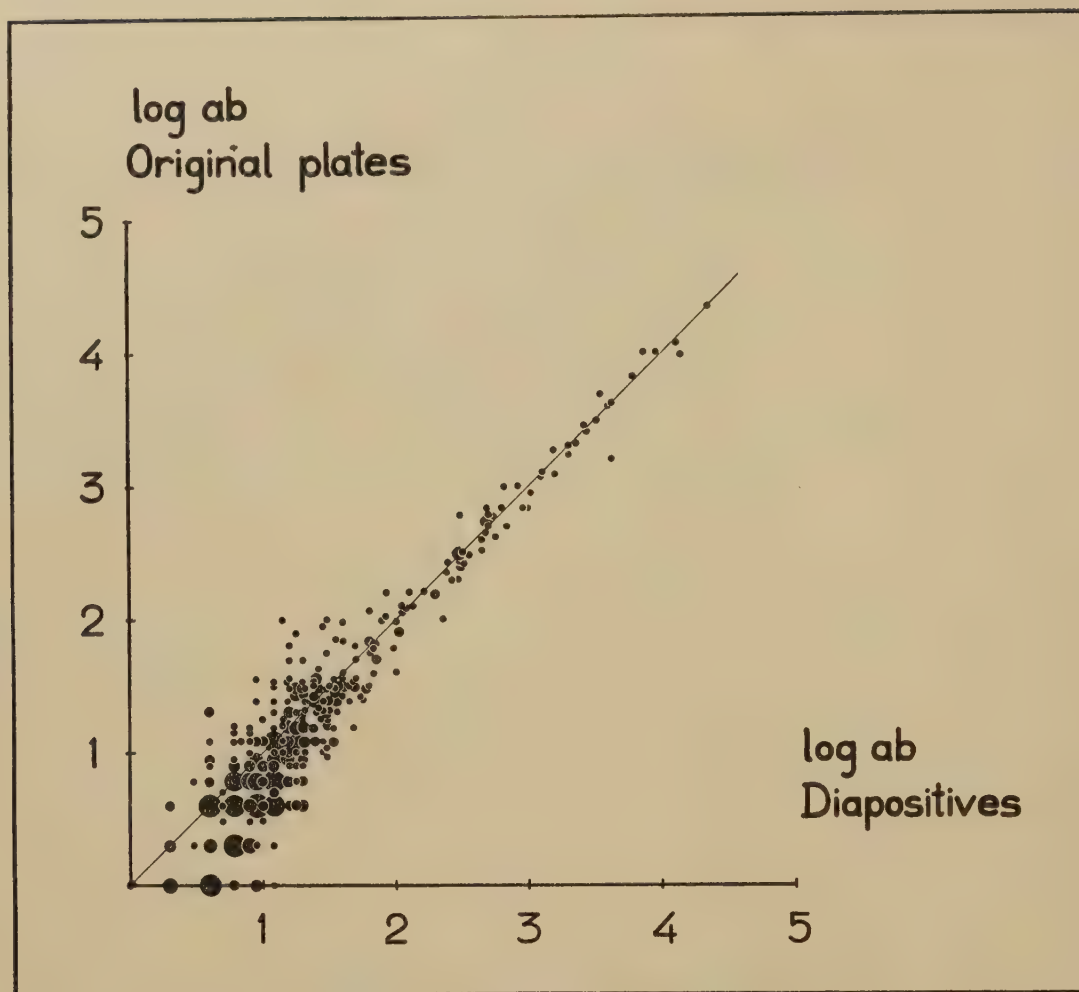


Fig. 18. Comparison between measurements of apparent dimensions on original plates and on diapositives for 445 Helwan objects.

against the limiting magnitudes. There was found to be no relation within the magnitude interval in question ($16^m.0$ to $18^m.6$). There is also not much reason to expect a relation, if we consider that a limiting magnitude star on any plate should be of approximately the same appearance and density. Perhaps a little more surprising was that a possible relation to the quality of the plate, given as the diameter of the limiting magnitude stars, was also tried without positive result. The reason for a negative result is probably that the limiting magnitude stars, even if the diameters differ, are, as said, of approximately the same density.

Dimensions. Next measurements of dimensions of the objects on the diapositives were carried out. The comparison between the dimensions on the originals and the diapositives is seen from Fig. 18, where $\log ab$ on originals and $\log ab$ on diapositives are put against each other. It is obvious that the dimensions for nebular images on diapositives show no very great deviation from the dimensions measured on the originals. Only for very small objects are the deviations somewhat prominent, but here the errors

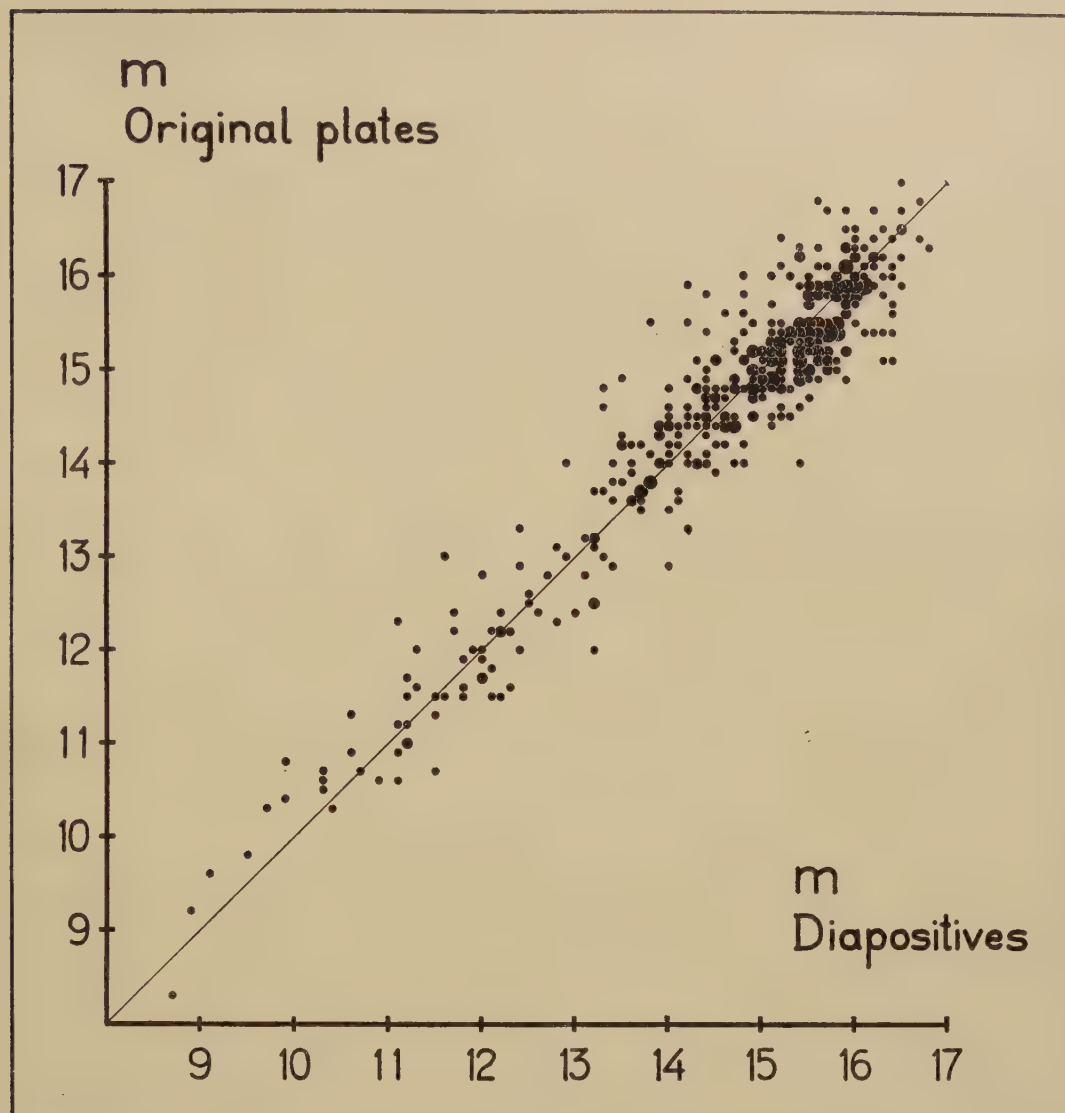


Fig. 19. Comparison between estimates of total magnitude on original plates and diapositives for 442 Helwan objects.

of measurement greatly influence the logarithm. This is obvious, since only the tenth of a millimetre is estimated, and $\log ab = 1.0$ signifies, for example, such a small object as 0.5×0.2 mm. That the diapositives come out with the somewhat larger images can be explained by the irradiation, the tendency of the eye to see white spread out over black, or also by the fact that an intensification in the blackness had taken place.

The mean between the two quantities was found to be

$$\overline{(\log ab)_{\text{orig}} - (\log ab)_{\text{diapos}}} = -0.11 \pm 0.01 \quad (n = 445)$$

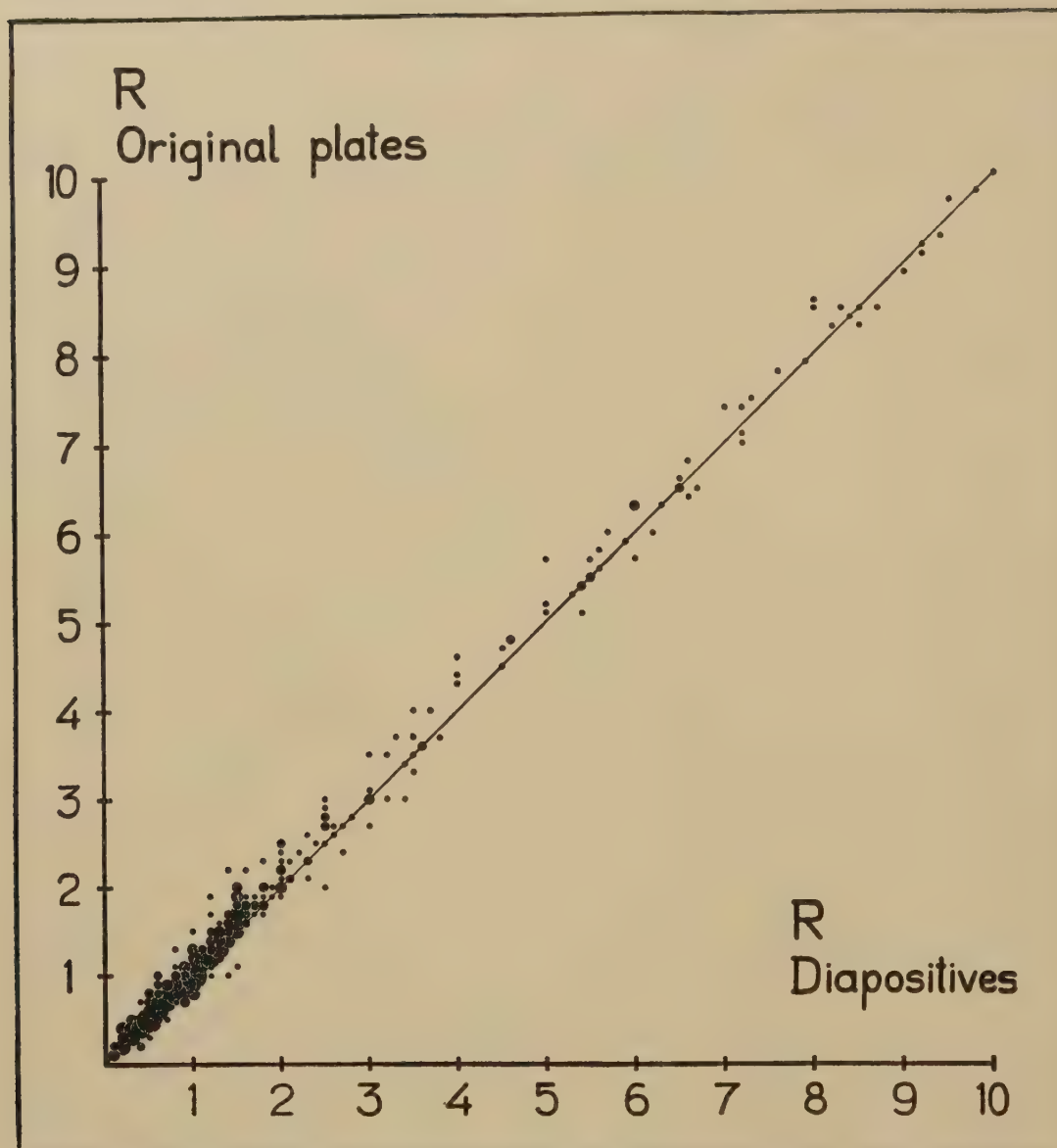


Fig. 20. Comparison between estimates of resolution class as determined on original plates and on diapositives for 442 Helwan objects.

Total magnitude. The determination of total magnitude on the diapositives, for altogether 442 anagalactic objects, was performed in the usual way by the help of limiting magnitude and intermediate magnitude stars, etc. As before, means were taken of two series of estimates. The relation of the two sets of magnitudes is shown in Fig. 19.

The correlation coefficient between the two variates was

$$r = + 0.940 \pm 0.005 \quad (n = 442)$$

Some loss of total magnitude might be expected, as the generally faint outer portions of the objects disappear to some extent in the copying. The loss is however not observable at all, as is seen from the figure, showing a very good run of the points along the 45° -line. Subjective influence can of course affect in a systematical way in either direction. The magnitude of the objects on the diapositives differed from those on the original plates only with $\Delta m = 0^m.02 \pm 0^m.02$, the former objects being the brighter.

Concerning the determination of integrated magnitude on diapositives it must be added that quite transparent parts of bright objects, for example bright nuclei, cannot be estimated with certainty. Such objects require to have been reproduced on plates with a very weak gradation.

Resolution. The structure is one of the most interesting features of the objects to be discussed from the point of view proposed. To get an estimation of the resolution class as certain as possible, only quite differential estimates can be brought into question. For the objects in general only very small differences, if any at all, could be detected. The result of the estimates appears in Fig. 20. As is well seen, only a very small loss of resolution prevails. The mean loss amounted to $\Delta R = 0^R.10 \pm 0^R.01$.

In some cases a gain in resolution appeared, caused by the fact that a change of gradation had taken place on the diapositives, seen as a better difference in density or even a better separation of different portions of the objects from one another.

Especially on diapositives we do have to pay attention to false objects, which often occur where a flow has happened to be fixed on the plate. Around the small black flow a nearly circular region of less intensity will usually appear. Phenomena of the same form also accidentally occur on originals, looking like round regions of less density.

Similar regions of actually less sensitiveness may occur on plates. As they, however, in most cases are marked by a central grain, I think we can presume, even when nothing is seen at the centre, there has from the beginning existed a disturbing body, which during the photographic treatment has been removed, either mechanically, or by being dissolved by the developer or, especially, by an acid hypo.

CHAPTER VIII.

THE RESOLUTION OF ANAGALACTIC OBJECTS PHOTOGRAPHED AT HELWAN, RELATED TO THE RESOLUTION OF OBJECTS ON DIAPOSITIVES OF PHOTOGRAPHS ORIGINATING FROM THE 60- AND 100-INCH TELESCOPES OF MT WILSON OBSERVATORY AND THE CROSSLEY REFLECTOR OF LICK OBSERVATORY.

It is a well-known fact that the resolution of a certain object increases in the same degree instruments of greater focal length are used, provided the ratio of focal length to diameter being the same and all other conditions constant. The problem of a comparison of the resolution of anagalactic objects photographed with different instruments can be attacked in two ways: firstly, the same objects can be compared one by one with regard to their resolution; secondly, for a great number of objects relations where the resolution is one of the variates can be compared.

In the present chapter both methods will be dealt with.

The material is the Helwan original plates discussed in the previous chapters, and a number of diapositives emanating from the 60- and 100-inch telescopes on Mount Wilson and the Crossley 36-inch reflector on Mount Hamilton. As has been shown, it can be considered that no appreciable differences exist with regard to the three properties in question, if the diapositives are good. I think the diapositives made use of here can be considered as very satisfactory. As in the diapositive material used by me, kindly put at disposal by Prof. LUNDMARK, many replicas are to be found, I have of course chosen the best diapositive in every case. Doubtful objects, as well as objects showing a gradation too steep to allow an estimation of integrated magnitudes, have been excluded. If the magnitude of such latter objects was known from other investigators, they have been included.

The comparison between the same objects on diapositives, or on diapositives and original plates emanating from different instruments, also clearly shows the excellence of the American diapositives. A comparison showed how well the objects agreed with another in their details, and only in very few cases were false objects found, which would have been included in the material, if their true nature had not been discovered by these comparisons.

A comparison of the resolution of the same objects photographed with different instruments. The number of objects in common on plates from the four instruments mentioned is not very great, even when counting them two by two. The material, however, was considered as sufficient enough to be worked through, the more as I am sure work on this subject has previously not been done. And what is more, it gives means for increasing my possibilities of comparing the present resolution classification with the visual classifications by the HERSCHELS, SCHULTZ and BIGOURDAN. Such a comparison must in fact be made with reference to a definite instrument, if there is to be any meaning in it. By investigating the systematics between the four instruments of which plates are at my disposal, I can, however, reduce the resolution class of an object obtained on a plate taken by a certain instrument to that of another.

It is to be noted that the estimates of resolution for the material to be discussed here were not made differential, but were made without any conscious knowledge of the objects on the other plates. The estimates were in fact scattered over years, and for different instruments intermingled with each other. This system of work was considered as most suitable until the scale was decisively fixed for the appearance of certain objects.

Firstly, I started with a comparison for the different instruments with the primary estimation material. After this, however, differential measurements were done for the objects which I had on more than one plate.

The estimates of resolution class for objects in common were grouped for the instruments two by two. In the first calculation the objects were divided into two lists, limited by $R = 5^R0$. In cases when this border was passed by one of the objects to be compared, the mean decided to which group they should be assigned. If the mean was exactly 5^R0 , the objects were brought to the lower group.

Denote the systematical differences between the instruments as follows:

$$\begin{aligned} \text{Helwan } 30'' - \text{Lick } 36'' &= x \\ \text{Lick } 36'' - \text{Mt Wilson } 60'' &= y \\ \text{Mt W. } 60'' - \text{Mt W. } 100'' &= z \end{aligned}$$

They are considered positive if the bigger instrument gives a better resolution. Then the systematic for Helwan 30" to Mt Wilson 60" amounts to $x + y$, and so on. From the computed differences a_i , based on a number of objects n_i , we get the following system of equations

$$\begin{aligned} (1) \quad x &= a_1 (n_1) \\ (2) \quad x + y &= a_2 (n_2) \\ (3) \quad x + y + z &= a_3 (n_3) \\ (4) \quad y &= a_4 (n_4) \\ (5) \quad y + z &= a_5 (n_5) \\ (6) \quad z &= a_6 (n_6) \end{aligned}$$

This system can be solved by the method of least squares. In our actual case we have for the a_i and n_i in the two groups, as well as for all objects together:—

$0.0 \leq R \leq 5.0$	$5.0 < R \leq 10.0$	$0.0 \leq R \leq 10.0$
$a_1 = + 0.14 \quad n_1 = 18$	$a_1 = + 0.71 \quad n_1 = 8$	$a_1 = + 0.32 \quad n_1 = 26$
$a_2 = + 1.97 \quad n_2 = 3$	$a_2 = + 1.20 \quad n_2 = 1$	$a_2 = + 1.77 \quad n_2 = 4$
$a_3 = + 1.17 \quad n_3 = 8$	$a_3 = + 0.64 \quad n_3 = 5$	$a_3 = + 0.97 \quad n_3 = 13$
$a_4 = + 0.39 \quad n_4 = 55$	$a_4 = + 0.55 \quad n_4 = 33$	$a_4 = + 0.45 \quad n_4 = 88$
$a_5 = + 0.82 \quad n_5 = 15$	$a_5 = + 0.34 \quad n_5 = 15$	$a_5 = + 0.58 \quad n_5 = 30$
$a_6 = + 0.50 \quad n_6 = 1$	$a_6 = + 0.20 \quad n_6 = 1$	$a_6 = + 0.35 \quad n_6 = 2$
(100)	(63)	(163)

As the number of observations in the separated schemes is small and the differences a_i for the same two instruments compared do not deviate systematically, I have considered it better to use the combined scheme in the computation. When this is done we obtain

$$\begin{aligned} x &= + 0^{\text{R}}42 \pm 0^{\text{R}}15 \\ y &= + 0.49 \pm 0.10 \\ z &= + 0.01 \pm 0.18 \end{aligned}$$

Before the result found here is discussed, we enter upon the differential measurements.

The objects were estimated *differentially* after placing the plates side by side. In this, the resolution value given to each object was learned, and after comparative examination of the objects, the resolution classes were eventually corrected. After this, the computations were carried out again. For all classes of resolution it was found that

$$\begin{aligned} a_1 &= + 0.28 \quad n_1 = 26 \\ a_2 &= + 0.87 \quad n_2 = 4 \\ a_3 &= + 0.84 \quad n_3 = 13 \\ a_4 &= + 0.33 \quad n_4 = 88 \\ a_5 &= + 0.60 \quad n_5 = 30 \\ a_6 &= + 0.35 \quad n_6 = 2 \end{aligned}$$

(163)

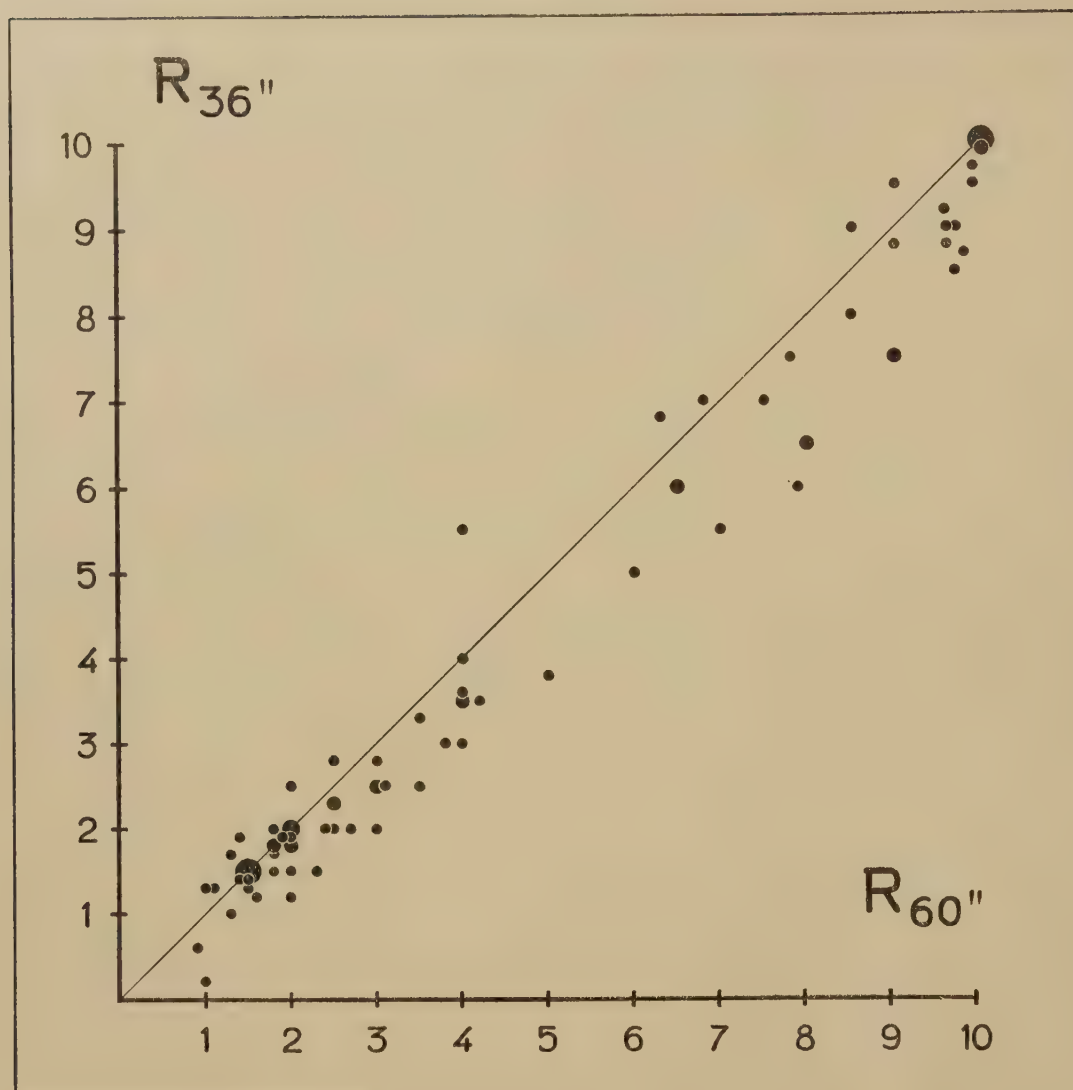


Fig. 21. Comparison between 88 anagalactic objects in common on diapositives from photographs taken with the 36-inch Crossley reflector of Lick Observatory and the 60-inch reflector of Mt Wilson Observatory.

From these we get

$$x = +0.33 \pm 0.09$$

$$y = +0.36 \pm 0.06$$

$$z = +0.13 \pm 0.10$$

As is clearly seen, these values are accordant with those previously found. When the plates were re-determined, it was also obvious that on the whole the original estimates were very satisfactorily performed. Except in a few cases, only minor corrections had to be applied.

Expressed in a complete way, the result obtained says that to the resolution classes found for the smaller instruments shall be added certain amounts to get the probable value of the resolution for the bigger instruments.

Given with one decimal, these differences are:

Helwan 30" — Lick 36"	$\Delta R = + 0.3 \pm 0.1$	($n = 26$)
Helwan 30" — Mt W. 60"	$\gg = + 0.7 \pm 0.1$	($n = 4$)
Helwan 30" — Mt W. 100"	$\gg = + 0.8 \pm 0.1$	($n = 13$)
Lick 36" — Mt W. 60"	$\gg = + 0.4 \pm 0.1$	($n = 88$)
Lick 36" — Mt W. 100"	$\gg = + 0.5 \pm 0.1$	($n = 30$)
Mt W. 60" — Mt W. 100"	$\gg = + 0.1 \pm 0.1$	($n = 2$)

It is clear that the values found here are mean values for all resolution classes. Further, it is clear that they are to be regarded as approximate. A more detailed comparison can only be made for the Lick-instrument and the 60-inch Mt Wilson-instrument, for which the number of objects in common is fairly large ($n = 88$). The mean error of the difference of resolution between these instruments is, as is seen above, also by far the smallest. The resolution classes for the objects in common here are plotted against each other in Fig. 21. From this we see that the resolutions run together at the top of the classification and also at the bottom, but elsewhere differ by rather constant amounts. The effect of the bigger instrument is most prominent for objects of an intermediate resolution. Some objects in the figure which are situated on the »wrong» side of the 45° -line are certainly there because they are found on plates of relatively short exposure with the 60-inch telescope.

From this diagram (for the said two instruments) or from the previously given mean values (for any two instruments) we are now able to transfer the resolution class of objects photographed with a certain instrument to that of another.

As said, the differences found here have not a quite general validity, but might be useful for the following part of this section. As has been made clear in previous chapters, many factors except the optical constants of the instrument influence the results. There is the optical quality of the mirror, the skilfulness of the observer, the atmospherical conditions, the properties of the plate material and so on, to repeat only some of the most important factors to be regarded.

In short we might say: the figures obtained here are mean values for the material in question. However, I think they answer well to what we have reason to expect from the instruments.

A comparison between the present and previously established classifications of resolution. A comparison of the present photographic classification of resolution with the visual classifications of the HERSCHELs, SCHULTZ and BIGOURDAN is of much interest, as well as the mutual comparisons between the visual scales. In the latter case the number of objects in common is very great. Such an investigation dealing also with other apparent properties of the objects has in manuscript already been worked upon by Prof. LUNDMARK. My work here will by arrangement with him be limited to a comparison of my photographic scale with some of the visual scales.

The difference in instrument and the change from visual to photographic observations must be clearly remembered in this connection. As a general rule, however, it is valid that every observer gives his highest grades to the best resolved objects and his lowest grades to the least resolved objects. The ends of the scales can thus always be brought to coincide.

Well suited for a comparison is the descriptive classification of J. HERSCHEL, which is much more detailed

Table 23. *A comparison between the resolution of anagalactic objects as estimated visually by H. SCHULTZ and from photographic plates by B. SVENONIUS.*

No	NGC	Designation used by SCHULTZ	R (SCHULTZ)	R (SVENONIUS)					m	log <i>ab</i>	Type	Remarks
				Helw.	Lick	60''	100''	Mean red. to Lick				
1	29	h 6	5		5.0			5.0	(13.2)	1.48	(S)	
2	83	h 17	3.3		4.0			4.0	(13.8)	1.64	(S)	
3	169	GC 82	3		4.5			4.5	(13.0)	1.00	(S)	
4	193	h 37	5		4.3			4.3	(13.0)	1.00	(S)	
5	205	GC 5058	5			7.0		6.6	10.8	3.02	<i>Ep</i>	
6	467	I 108	3.5		6.0			6.0	(12.6)	2.29	(S)	
7	628	h 142	4.5		9.9	10.0		9.9	11.2	3.89	<i>Sc</i>	
8	772	h 181	5		6.3			6.3	12.0	3.09	<i>Sb</i>	
9	2275	h 407	5			2.0		2.0	(14.0)	0.88	(E)	Poor agreement
10	2681	h 530	5		4.7			4.7	11.3	1.66	<i>Sa</i>	
11	2683	h 532	3		7.0	6.8		6.7	10.8	3.98	<i>Sc</i>	
12	2841	h 584	3		8.8	9.0		8.7	10.5	3.17	<i>Sb</i>	
13	2903	I 56	3.5		9.2	9.6	9.8	9.2	10.3	3.54	<i>Sc</i>	
14	2964	h 622	3.3			8.5		8.1	11.9	2.43	<i>Sc</i>	
15	2968	h 624	4.5		6.3			6.3	12.8	2.39	<i>I</i>	Degenerated spiral
16	3034	M 82	3		5.5	7.0		6.0	9.4	3.04	<i>I</i>	Magellanic Cloud
17	3077	h 658	4		5.5	4.0		4.6	11.4	2.24	<i>I</i>	» »
18	3351	h 743	5		7.4			7.4	11.5	3.13	<i>SBb</i>	
19	3367	h 748	3.3			6.8		6.4	12.3	2.52	<i>S</i>	
20	3377	h 754	3			2.0		2.0	11.6	1.97	<i>E</i>	
21	3379	h 757	5			1.5		1.5	10.8	1.36	<i>E</i>	These two objects evidently overestimated by SCHULTZ.
22	3384	h 758	5			2.5		2.1	11.3	2.19	<i>SBa</i>	
23	3389	h 761	4		7.0	7.5		7.1	12.6	2.25	<i>Sc</i>	
24	3395	h 765	4			6.5		6.1	12.4	2.18	<i>Sc</i>	
25	3504	h 810	5		4.5			4.5	11.7	2.21	<i>SBb</i>	
26	3593	h 840	5			5.2		4.8	12.4	2.43	<i>Sb</i>	
27	3623	h 854	4		7.0		7.5	7.0	10.5	3.10	<i>Sb</i>	
28	3627	h 857	4		8.5		9.2	8.6	9.9	3.29	<i>Sb</i>	
29	4192	h 1132	3		8.0		8.2	7.8	11.4	3.02	<i>Sb</i>	
30	4214	h 1146 α	5		9.6		10.0	9.6	10.7	3.72	<i>I</i>	Magellanic Cloud
31	4216	h 1148	2.3			5.5		5.1	11.3	3.16	<i>Sb</i>	
32	4254	h 1173	2.3	9.0	9.0	9.7		9.2	10.5	3.40	<i>Sc</i>	Poor agreement
33	4281	h 1187	2.5		5.1			5.1	12.2	2.23	<i>Sa</i>	
34	4374	h 1237	3			1.5		1.5	10.9	1.97	<i>E</i>	
35	4382	h 1242	3		2.5			2.5	10.5	2.86	<i>E</i>	
36	4387	h 1250	3			2.0		2.0	(12.8)	1.27	(E)	
37	4388	h 1244	2			3.5		3.1	12.2	3.10	<i>S</i>	
38	4472	h 1294	2		2.0	2.0		2.0	10.1	2.22	<i>E</i>	
39	4486	h 1301	2		2.0			2.0	10.7	2.07	<i>E</i>	

No	NGC	Designation used by SCHULTZ	R (SCHULTZ)	R (SVENONIUS)					m	$\log ab$	Type	Remarks
				Helw.	Lick	60"	100"	Mean red. to Lick				
40	4536	h 1337	5		9.0			9.0	11.2	3.25	<i>Sc</i>	Poor agreement
41	4552	h 1348	4			2.0		2.0	11.3	1.85	<i>E</i>	
42	4564	h 1356	3		2.0	2.4		2.0	12.1	1.64	<i>E</i>	
43	4565	h 1357	4.5			8.5		8.1	10.7	3.26	<i>Sb</i>	
44	4567	h 1358	5		6.5	8.0		7.1	12.3	2.60	<i>S</i>	
45	4568	h 1359	5		6.5	8.0		7.1	12.2	2.32	<i>S</i>	
46	4569	M 90	5				6.5	6.0	11.2	2.26	<i>Sc</i>	
47	4594	h 1376	3.5	3.5		4.5		4.0	8.1	3.02	<i>Sa</i>	
48	4621	h 1386	2			1.5		1.5	11.4	2.13	<i>E</i>	
49	4647	h 1405	3			8.5		8.1	12.0	3.02	<i>S</i>	
50	4649	h 1408	2			2.0		2.0	10.6	3.10	<i>E</i>	Probably one single object
51	4656	h 1414	5		8.5	9.7		8.9	11.3	3.27	<i>I</i>	
52	4657	h 1415	5		8.6	9.7		9.0	(12.3)	1.52	(<i>I</i>)	
53	4725	h 1451	3		9.0		9.5	9.0	10.8	3.43	<i>SBb</i>	
54	4826	h 1486	3		6.0	6.5		6.1	8.0	3.32	<i>Sb</i>	
55	5005	h 1547	3		6.8	6.3		6.4	11.3	2.81	<i>Sc</i>	Magellanic Cloud
56	5194	h 1622	4		10.0	10.0		10.0	10.1	3.93	<i>Sc</i>	
57	5195	h 1623	4		6.0	6.5		6.1	11.1	2.62	<i>I</i>	
58	5560	h 1778	5			5.8		5.4	(13.3)	2.11	(<i>Sa</i>)	
59	5566	h 1779	4		3.8	5.0		4.2	11.9	2.31	<i>SBb</i>	
60	5746	h 1874	3		6.0	7.9		6.8	11.8	2.71	<i>Sb</i>	Poor agreement
61	7217	h 2149	2		8.8	9.6		9.0	11.6	2.88	<i>S</i>	
62	7479	h 2205	3		7.5	9.0		8.1	11.9	2.94	<i>SBc</i>	

than that of W. HERSCHEL. An attempt to translate the letter symbols used by J. HERSCHEL¹ into my numerical scale gives the following approximate values:

- st. (0.0 — 1.0): stellar
- com. (1.5 — 3.0): cometic
- i. (= iF) (2.0 — 3.0): irregular (irr. Figure)
- mn. (3.0 — 5.0): milky nebulosity
- r. (5.0 — 6.0): resolvable, barely (mottled as if with stars)
- rr. (6.0 — 8.0): partially resolved — some stars visible
- er. (8.0 — 9.0): easily resolvable
- rrr. (9.0 — 10.0): well resolved — clearly seen to consist of stars.

Thus in fact eight grades of resolution are given here. A noteworthy arrangement, made by me, is the addition of the first three classes of the scale. J. HERSCHEL further gives such denotations as c = compressed and dif. =

¹ Phil Trans Roy Soc of London (1864) p. 11.

diffused, which do not mean a certain class, but when attributed to the description will give a new grade of it. J. HERSCHEL does not estimate the resolution very systematically, and the number of objects common to my material and his catalogue for which the resolution is given is not great. A preliminary investigation shows, however, that a satisfactory agreement of the equalities proposed above is valid.

A comparison with H. SCHULTZ will be given here in detail, in obedience to a request by Prof. LUNDMARK. The observations by SCHULTZ are well-known for their accuracy in the position of the objects, altogether 525 in number. His observations were made with the Steinheil 13-foot refractor at Uppsala in the years 1863—1880.

SCHULTZ estimates the resolution in a five grade scale, the grades numbered 1 to 5. If he has observed an object more than once we may have two different figures for the resolution. In such cases I have chosen the mean of the figures, considering them of equal weight. Of about 80 objects common to our lists only 62 are attributed definite values by SCHULTZ. In the other cases he has given a figure 0, meaning that he was not able to estimate the resolution of the object.

The list of the 62 objects is given as Table 23. In this table there follow in order: running number, NGC-number, number used by SCHULTZ, resolution class given by SCHULTZ; further follow the resolution classes from my lists for the Helwan, Lick, 60-inch and 100-inch Mt Wilson instruments, and the resolution class reduced to the Lick-instrument. If the object was found on plates from more than one instrument, a mean was taken by using the systematics between the instruments found above. In the case of the highest resolution, where the differences are anomalous, slight modifications were made. For a resolution class $R \leq 2.0$ no correction has been applied. Finally I also give the total magnitudes and $\log ab$, mean values taken in applicable cases, and the type of the objects. The magnitudes and the types are either taken from the SHAPLEY-AMES catalogue or estimated by me, in which latter case they are given within brackets. The dimensions are measured by me.

The relation expected between R by SCHULTZ and R by the author gives a correlation coefficient which is probably real but low. There is found

$$r = +0.20 \pm 0.12 \quad (n = 62)$$

Highly contributing to this low value is that some objects are found to deviate very much. Of these NGC 4254 and NGC 7217 are underestimated by SCHULTZ. In the case of his observations of NGC 4254 the sky was rather light, which might explain the result. Otherwise the object is not faint, as $m = 10^m5$. In the case of NGC 7217 the observation nights were also not good. The faint outer portions of this very beautiful and interesting object have certainly escaped the notice of SCHULTZ.

Of the objects overestimated by SCHULTZ NGC 2275, NGC 3379 and NGC 3384 are the most deviating. They look elliptical on the diapositives and have thus a small photographic resolution. Of these NGC 3384 has the type *SBa* according to HUBBLE, and on good photographs its resolution class is thus greater than that of an elliptical object. But the outer portions of the object have also certainly not been observed by SCHULTZ. So this will not explain the deviation. There must be reasons why SCHULTZ often overestimates elliptical objects. It might happen that faint foreground-stars have been glimpsed by him and supposed to belong to the objects.

Excluding the five objects mentioned, the coefficient of correlation is

$$r = +0.40 \pm 0.11 \quad (n = 57)$$

I think this value might answer better to a relation between the classification by SCHULTZ and to a photographic classification in my sense.

It is to be noted that SCHULTZ has no object of class 1 in this common list.

In the NGC-catalogue DREYER notices that SCHULTZ should have observed NGC 20, situated near NGC 29, but this seems not to have been the case.

Relations between the resolution class and other apparent properties of the objects as compared for different instruments. — Relations of R with $\log ab$. The estimated resolution and the measured dimensions, the latter quantity given as $\log ab$, are put against each other and given for the four instruments in Fig. 22, 23 and 24. The unit of length is as before the tenth of a millimetre. As is seen for all instruments, the relation between R and $\log ab$ can approximately be expressed by a straight line. The dispersion around the line is considerable, even if the lowest and the highest portions are excluded. The cause of the fairly great dispersion is that objects of a very different character are contained in the material. This is especially marked for the 60-inch material. As before, elliptical objects are marked with open circles. They form a line for themselves with much less slope than the main branch of the objects. Some strange types of objects, being: »The Eye-nebula», »Magellanic Clouds» and others, deviate somewhat from the general run. They are, however, not remarkably deviating. They are as a rule very well-known objects. An interesting feature of many deviating objects is the existence of absorbing matter, which generally has a diminishing effect on the resolution of the objects as compared with what could be expected from their dimensions.

The drawing of straight lines has been done purely graphically, this being considered a sufficiently accurate method. The equations of the lines are in order with increasing dimensions for the four instruments as follows

$$\begin{array}{llll} (30\text{-inch reflector}) & \log ab - 0.32 R = 0.75 & (n = 461) \\ (36\text{-} \gg \gg) & \log ab - 0.34 R = 0.75 & (n = 443) \\ (60\text{-} \gg \gg) & \log ab - 0.34 R = 0.85 & (n = 459) \\ (100\text{-} \gg \gg) & \log ab - 0.37 R = 1.15 & (n = 103) \end{array}$$

The number of observations totally contained in the figures on which the equations have been based are also given.

As is well seen, the slope of the lines and the constant term are very similar, growing a little, however. Only the line of the 100-inch reflector deviates somewhat, the number of objects being, however, in this case appreciably less. The agreement of the equations must be interpreted so that it is the dimensions of the images on the plates which determine the resolution. This means that the focal length is the only factor to be considered: let us remember however that the ratio focal length to diameter is approximately constant for the instruments in question. If the diameter of the mirror of an instrument of a certain focal length is diminished, we can be sure that the resolution class of certain objects will diminish too.

If we want to reduce the $\log ab$ in the equations from tenths of a millimetre on the plate to tenths of a minute of arc, this can be done by the knowledge that

$$\begin{array}{llllll} 1' \text{ for the 30-inch Helwan reflector answers to } 1.0 \text{ mm} \\ 1' \gg \gg 36\text{-} \gg \text{Lick} \gg \gg 1.55 \gg \\ 1' \gg \gg 60\text{-} \gg \text{Mt Wilson} \gg \gg 2.2 \gg \\ 1' \gg \gg 100\text{-} \gg \gg \gg \gg 3.7 \gg \end{array}$$

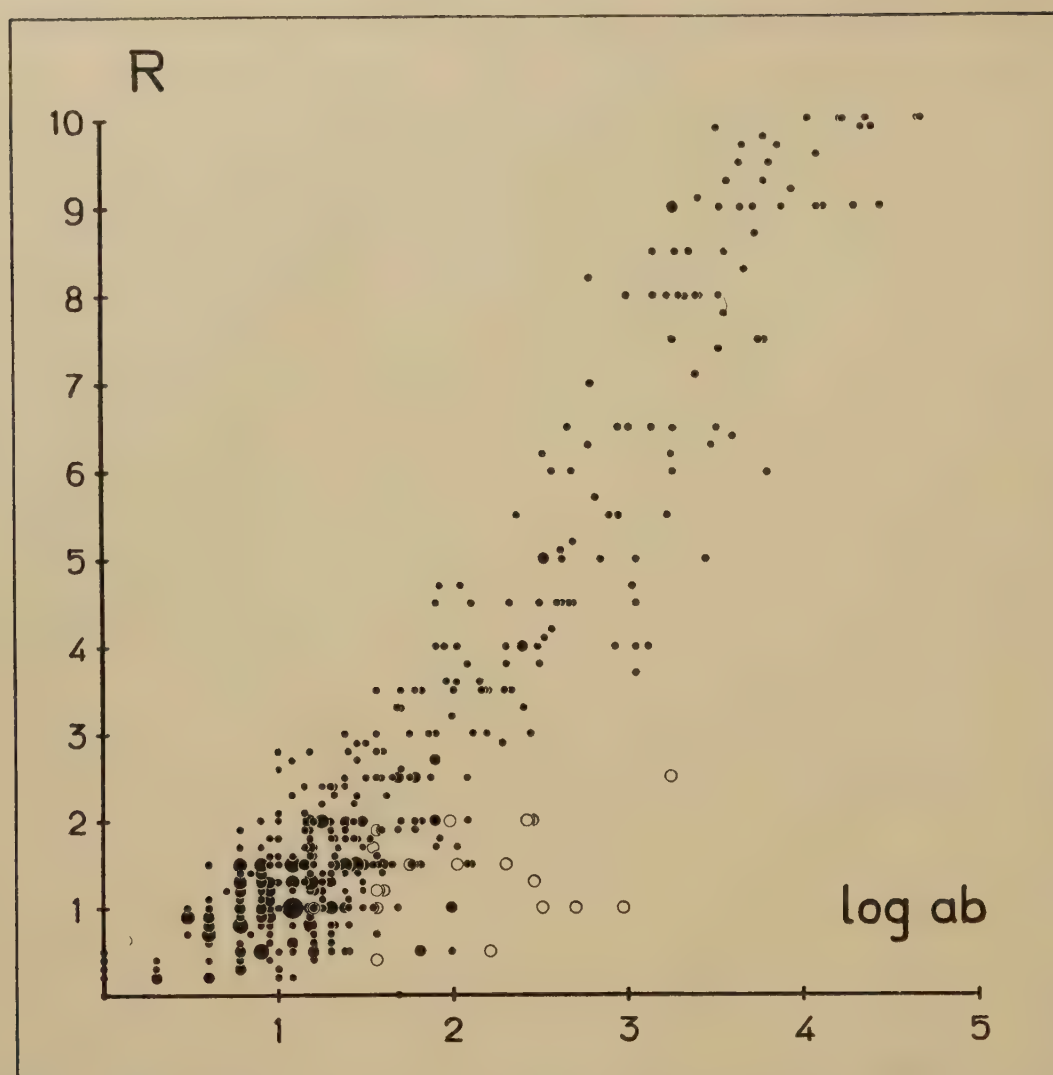


Fig. 22. Relation between resolution (R) and apparent dimensions ($\log ab$) for 443 anagalactic objects photographed with the 36-inch Crossley reflector of Mt Hamilton. Diapositives used.

Then the above equations take the form

$$\log ab - 0.32 R = 0.75$$

$$\log ab - 0.34 R = 0.37$$

$$\log ab - 0.34 R = 0.17$$

$$\log ab - 0.37 R = 0.01$$

only the constant term being altered. By the great change of the constant term, which now decreases, we have a still better view of how overwhelmingly the dimensions on the plate determine the resolution. Strictly, however, a slight correction into an intermediate value would be the best.

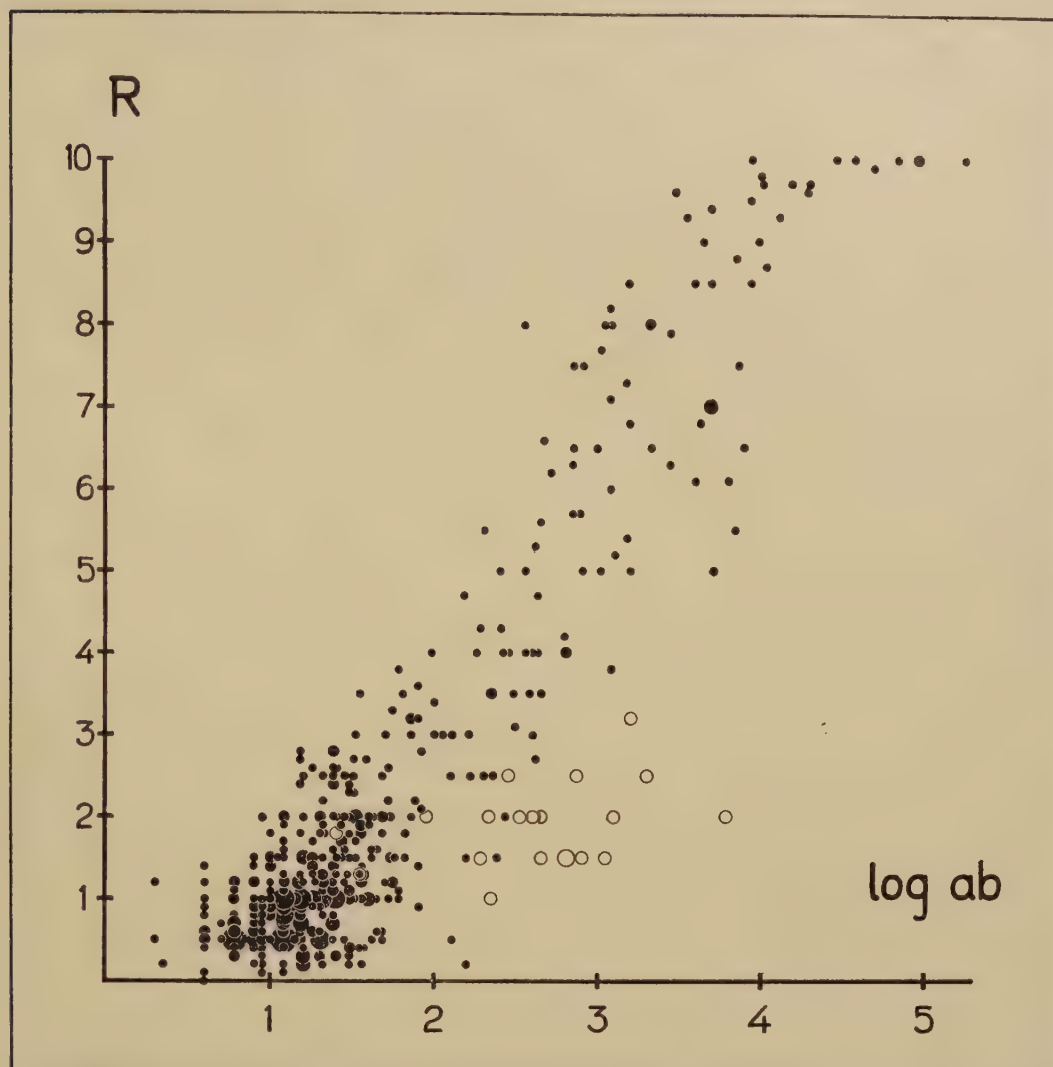


Fig. 23. Relation between resolution (R) and apparent dimensions ($\log ab$) for 459 anagalactic objects photographed with the 60-inch reflector of Mt Wilson. Diapositives used.

If we consider the change in angular coefficient of the lines as real, which hardly can be the case, it says that for the bigger instrument the slope of R against $\log ab$ slightly increases.

Relations between resolution class and total magnitude. The total magnitude (m) for the same material as before is put against the resolution class (R) in the Fig. 22—24. The relations between the two quantities can be approximately expressed by straight lines here too. The lines are placed graphically, and take no account to the lowest and the 10^R0-portion of the point groups. The asymptotical character of these two limits is very obvious. Here also the elliptic objects are designed by open circles, and as they are inclined with a much less slope, they are not included when the lines are placed.

The lines for the four instruments (Helwan included) are as follows

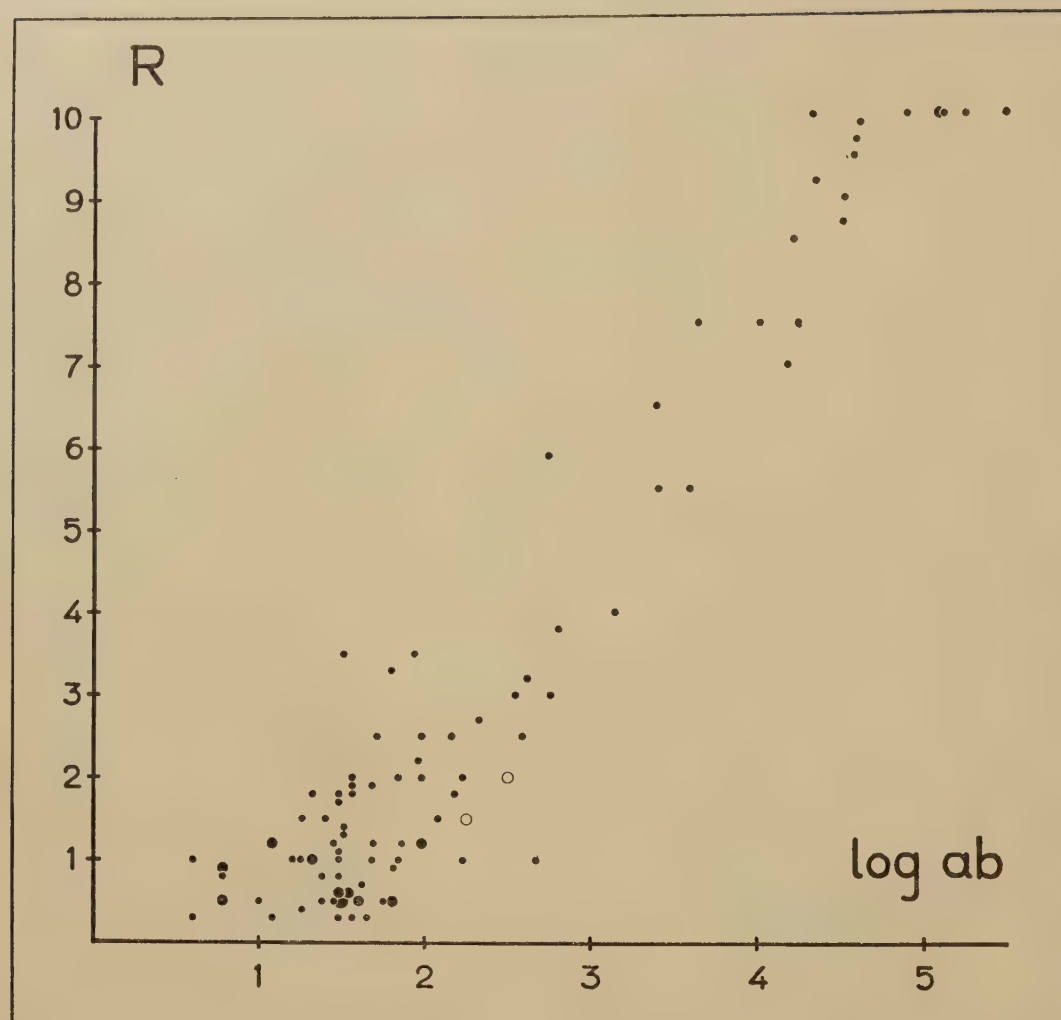


Fig. 24. Relation between resolution (R) and apparent dimensions ($\log ab$) for 103 anagalactic objects photographed with the 100-inch reflector of Mt Wilson. Diapositives used.

$$\begin{array}{llll}
 (30\text{-inch reflector}) & m + 0.60 R = 15.8 & (n = 461) \\
 (36\text{-} \gg \gg) & m + 0.58 R = 16.0 & (n = 443) \\
 (60\text{-} \gg \gg) & m + 0.67 R = 16.8 & (n = 459) \\
 (100\text{-} \gg \gg) & m + 0.76 R = 17.5 & (n = 103)
 \end{array}$$

The number of observations totally contained in the figures on which the equations are based is also given.

From the equations we see that the slope of the lines is approximately the same, whereas the constant term increases with the dimensions of the instrument. These statements mean that for a given instrument a certain magnitude is required on an average to give a certain resolution. For the bigger instrument the

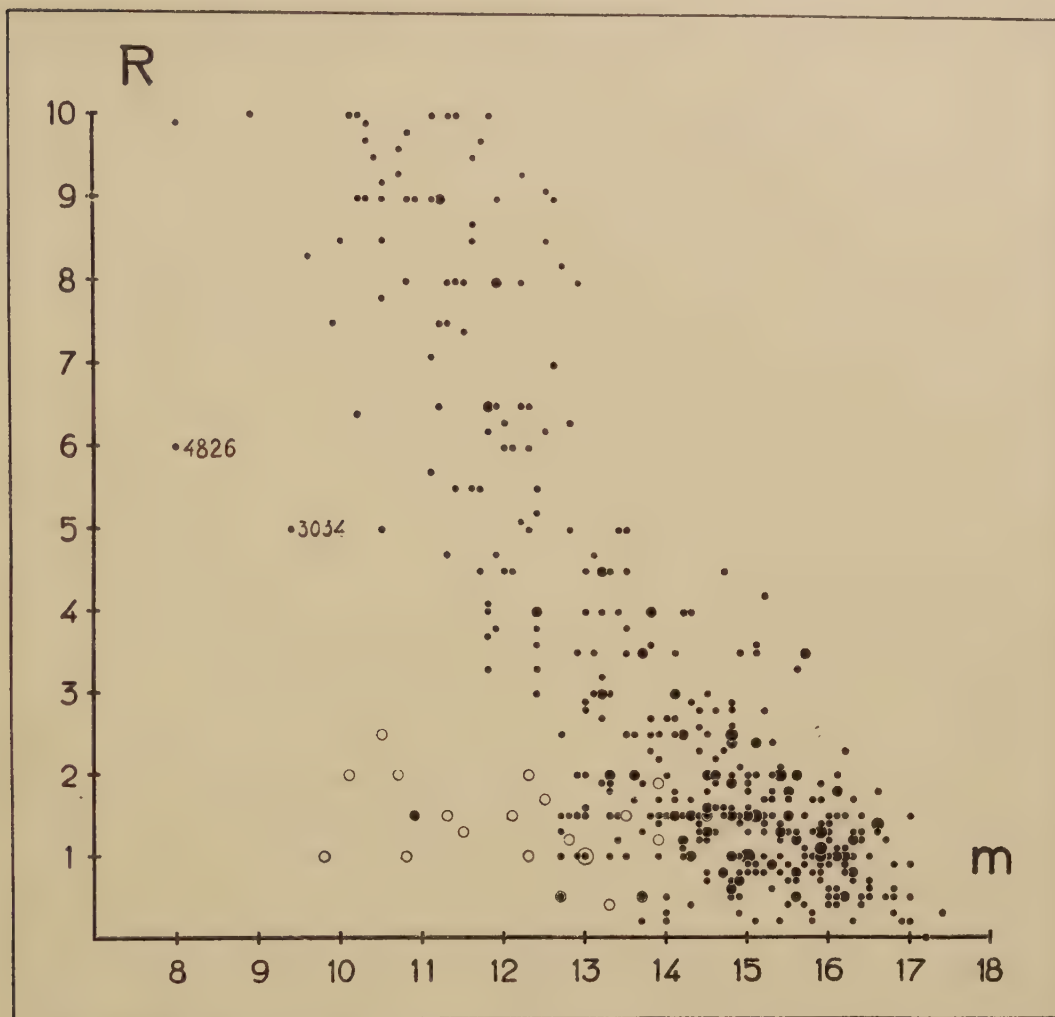


Fig. 25. Relation between resolution (R) and total magnitude (m) for 443 anagalactic objects photographed with the 36-inch Crossley reflector of Mt Hamilton. Diapositives used.

magnitude is fainter for one and the same resolution. The fairly constant slope means that the lines run nearly parallel, and thus can be brought approximately to coincide when transferred along the magnitude axis.

As a standard for the *capacity of resolution* of anagalactic objects by a certain instrument I introduce the mean magnitude for the resolution class 5^R_0 . For the instruments here the figures thus defined are

(30-inch reflector)	$m_{5^R_0} = 12^m.8$
(36- » »)	$m_{5^R_0} = 13.1$
(60- » »)	$m_{5^R_0} = 13.4$
(100- » »)	$m_{5^R_0} = 13.7$

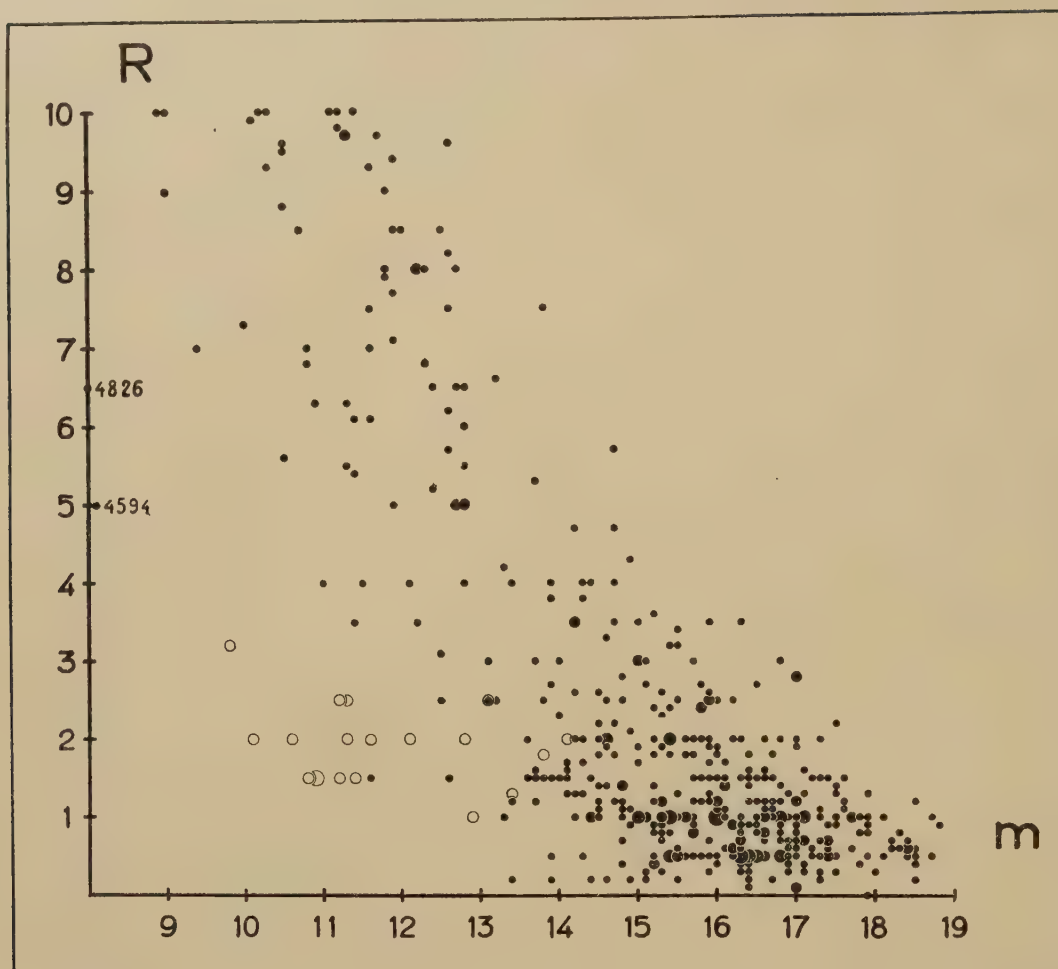


Fig. 26. Relation between resolution (R) and total magnitude (m) for 459 anagalactic objects photographed with the 60-inch reflector of Mt Wilson. Diapositives used.

Here we see that this magnitude gets fainter for the bigger instruments, as is also expected, although the change is not considerable. Of course the character of the objects contained in the material for every instrument will influence the result. It is hoped that no serious selection of the objects is to be found in the present material. For a larger material the run of the lines will of course be more stable. Three objects which appreciably deviate from the general run are given in the figures by their NGC-numbers.

Finally, it must be made clear that the gain in limiting magnitude, when instruments are compared, will not correspond, even for the same ratio of focal length to diameter. This is because not only does the instrument determine the resolution of the objects, but do other factors enter which are considered here as approximately constant for all instruments compared.

The optical quality of the mirror will contribute to the resolving power of an instrument. It is well-known that the 60-inch reflector is an instrument of especially excellent optical qualities. In the general resolution this fact seems, however, not greatly to contribute to an improvement of the figures regarding R .

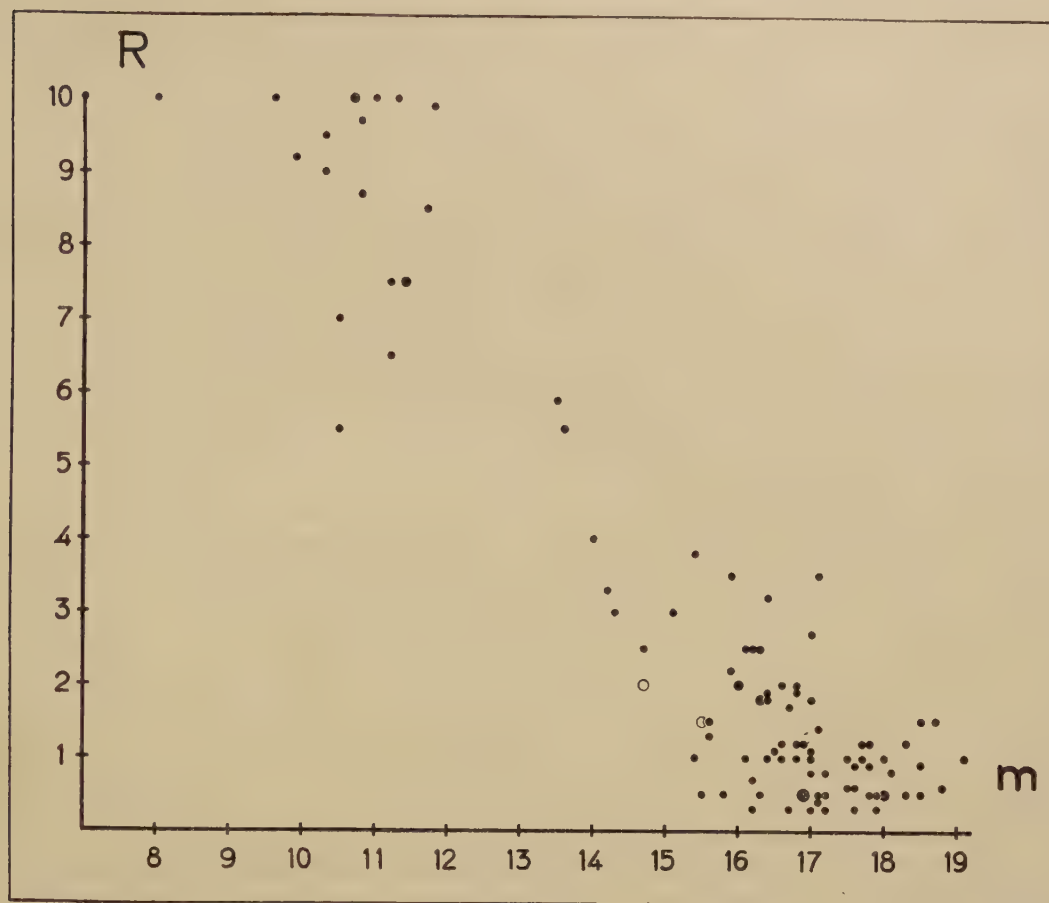


Fig. 27. Relation between resolution (R) and total magnitude (m) for 103 anagalactic objects photographed with the 100-inch reflector of Mt Wilson. Diapositives used.

In addition to the capacity of resolution given above, the mean limiting magnitude of the plates are of interest. They are as follows

(30-inch reflector)	$\bar{m}_{\text{limit}} = 17^m.4 \pm 0^m.1$	($n = 54$)
(36- » »)	$\bar{m}_{\text{limit}} = 18.2 \pm 0.1$	($n = 74$)
(60- » »)	$\bar{m}_{\text{limit}} = 18.7 \pm 0.1$	($n = 62$)
(100- » »)	$\bar{m}_{\text{limit}} = 19.3 \pm 0.2$	($n = 17$)

We can also turn the problem, and compute the differences in resolution existing between the instruments for a certain mean total magnitude. Let us choose as this magnitude $m = 13^m.0$. Then the lines give

(30-inch reflector)	$m = 13^m.0.$	$R = 4.67$
(36- » »)	$m = 13.0.$	$R = 5.17$
(60- » »)	$m = 13.0.$	$R = 5.67$
(100- » »)	$m = 13.0.$	$R = 5.92$

The differences between the R -values give directly the change in resolution from one instrument to another. When they are compared with the corresponding values obtained by the first method, dealing with same objects photographed with different instruments, we find that the figures stand in satisfactory relation to each other. We now have: $x = 0.50$, $y = 0.50$ and $z = 0.25$.

In connection it is to be noted that a comparison between the author's photographic scale and anyone of the visual scales, or between any two of the visual resolution scales, can be made by the lastly given method: to relate the resolution class to the magnitude of a large number of objects.

It is my hope later on to be able to estimate the resolution class for a greater material than the present, in order to fix the results found here still more. I also wish to extend the above material to nebular plates taken with other instruments. Another point is, even if it will probably not much affect the results, that differential measurements and better magnitudes can be determined, and also that original plates can be used. No correction was made for the fact that the Helwan plates were originals.

CHAPTER IX.

PHOTOMETRICAL STUDIES OF STRUCTURES OF ANAGALACTIC OBJECTS.

A. STRUCTURES OBTAINED BY MEASUREMENTS WITH MICROPHOTOMETERS.

For recording structures or contouring borders of anagalactic objects, microphotometers are of good help. In the present investigation comparative measurements on some chosen objects were carried out in a Schilt photometer and a self-recording microphotometer of the Moll-Krüß type, both instruments belonging to the Stockholms Observatorium, Saltsjöbaden. Besides, these objects were also photometrically measured by using the number of developed silver grains as a photometric indicator, on which measurements we shall enter in the next part of this chapter.

Not all anagalactic objects are well suited for a photometry of their structural properties, at least not without having been transferred from the original plate and enlarged on a diapositive. For the slit must, for giving sufficient deviations on the galvanometer, be kept of certain, not too small dimensions. In the present investigation it was about 0.20 and 0.25 mm respectively for the Schilt and the Moll-Krüß photometers. Contrary to this difficulty, if the object is too extensive, a photometry means a very great work. With regard to faint objects, a photometry has its given value, as by the aid of this the possibility exists that faint structures, or intensities in general, may be detected or recorded, which for the naked eye are seen with difficulty and are still more difficult to describe.

The objects on which the comparative investigations have been carried out are: NGC 1097, NGC 1365, NGC 4731, NGC 5496 and NGC 5861. (See the Plates of this paper.) Of the three first mentioned objects

only the nuclear regions have been examined, through their rather complicated structures being of considerable interest. NGC 1097 is a well-known, large barred spiral, of which the bright nucleus is divided into at least five parts, separated from each other. NGC 1365 is either a double spiral or is, like the previous object, a barred spiral, with a double nucleus, consisting of two parts of approximately the same size and form. NGC 4731 is a nice spiral of well formed symmetry and with nuclear condensations along its straight central portion. According to the writer NGC 5496 is a Magellanic Cloud, being small and as seen by the eye fairly well bounded.

With regard to NGC 5496 there are three stars visible over its surface. These are probably projected against the surface, although the probability that three stars of the magnitude of theirs are seen against such a small surface is only about 1/100. This figure is found by star counts on the plate within a certain surface and a subsequent comparison with the surface of the object. On one at least of these stars, namely the one that is lying single (Plate 6), is it prominent that the nebula does not reach the star but just seems to bend round it. This however, could possibly be explained as an EBERHARD effect, thus resulting from the development. The developer absorbed by the gelatine is considered to be strained by the development of the relatively bright star, and then the development of the surrounding nebular region goes on more slowly. This effect is best known for close stars, and is easy to show by a photometry perpendicular to a series of strong, close density bands on a photographic plate.

Quite the same effect as described here for NGC 5496 was found in Lick Publ. Vol VIII (1908, Plates 10 and 12) for some objects. The effect is described in a note inserted at the first page of the volume, but no explanation is given to it.

The principles of a photometry of anagalactic objects are very simple. The density above the fog or background of the plate is measured with the photometers in the usual way. From the resulting densities there was made what could be called a mapping of the objects, and on these maps lines of equal density (isodenses), corresponding also, at least approximately, to lines of equal intensity (isophotes), were drawn. It has been considered as suitable to express the density as per cent of light absorbed in every point of the object, although, as only isophotes are wanted, also the unreduced deviations or the deviations multiplied by any factor can be used with the same result. The density can of course also be expressed in the usual way (see e. g. Chap. III) as the logarithm of the ratio between the intervals »clear plate to full blackness» and »density in the object to full blackness».

The measurements performed in both photometers gave, as expected, much the same results. As I found it easier to have a better control of the position on the plate in the Schilt photometer than in the Moll-Krüss photometer, which latter was not provided with suitable scales for my purpose, I give only the results from the Schilt photometer in detail. The use of a self-recording microphotometer also agrees with this on the whole.

With regard to the description and principles of the Schilt photometer, as well as to its use in different branches of photometry, I refer to papers by J. SCHILT,¹ K. G. MALMQUIST² and Y. ÖHMAN.³ The measurements in the Schilt photometer were performed in this way: a small squared aperture, being of such size that its image on the plate was 0.2×0.2 mm, was made to pass over the object. By the measurement so to say a division

¹ BAN 1 (1922) p. 51; 2 (1924) p. 135. Groningen Publ Astr Lab 32 (1924).

² Stockholm Ann 12:7 (1936) p. 7.

³ Upsala Medd 48 (1930) p. 18 etc and p. 32 etc.

of the object into parallel bands of 0.2 mm breadth was obtained. The repeated displacement of the slit by 0.2 mm within the same band, or the displacement of the same amount when the following band is entered upon, is commodiously done by the vertical and the horizontal scales of the photometer. As the photometer used was not provided with a nonius, the displacements had to be made by estimation of fractions of the space between two neighbouring millimetre-lines. Every square millimetre on the plate thus means 25 settings. An object of a size of about 40 mm² (corresponding to a square of about 6 mm side), which is not very much, thus requires about 1000 settings, and an object of the surface 1 cm² requires 2500 settings. As the 1000 settings require a time of say 6 hours, it is easily seen that an object of even the least of the dimensions mentioned will require a good day's work at the photometer. If the writing down of the readings can be done by another person, however, a good deal of time is saved. Also the time needed greatly depends on whether the photometer works steadily, so that the thread quickly stops at its final place.

For knowing that the photometer is working constantly, or for taking a variation of the E.M.F. of the thermoelement for the same exciting conditions into account, it is at times necessary during the work to put the aperture on the same control-place on the plate. For the sake of exactness and simplicity this place of course ought to be constantly blackened over a relatively extensive region. If not, an accurate position must be given to the aperture on the plate, if the control is not to be illusory. At the measurements performed, such controls were repeated after I had finished with every or with every second band. The setting on »clear plate» and »full blackness», of which the first mentioned in practice answers to the control setting, have both been given the same frequency as the mentioned control manipulation.

For attaining the best possible constancy of the photometer, which for measurements of the present kind is especially wanted owing either to the very small deviations of blackness within an object or to the faintness of the object, some conditions proved to be particularly advisable to take into account. If the photometer is not completely isolated from shaking, the working day must be of quiet weather. Further, the photometer lamp must not be too old, for then it showed unsteadiness. Finally, if a variable resistance is made use of for counterbalancing changes, or if a resistance is coupled in the current without being used, it must in any case be provided with good contact points.

A more detailed list of factors affecting accuracy in measurements with the Schilt photometer is given in the mentioned paper by ÖHMAN.¹

The results of the measurements of the anagalactic objects appear in the Plates 8—10, 12 and 14. A detailed comparison with the measurements by counts of silver grains, which we are now going to enter upon, shows that the isophotes drawn by both photometric methods have a corresponding run, and as compared with the microphotographs record the objects with a satisfactory accuracy.

¹ L. c., p. 32.

B. STRUCTURES OBTAINED BY MEASUREMENTS BASED ON COUNTS OF DEVELOPED SILVER GRAINS.

In astronomical photometry some practical use has been made of the counting of developed silver grains on photographic plates. Thus W. KREBS¹ used the number of grains counted along two perpendicular axes in the ring nebula in Lyra (NGC 6720) in order to get expressions for the relative intensity distribution in these directions. Another instance was given by E. PETTIT,² who in an investigation on the accuracy of a registering microphotometer compared a microphotometer curve with a frequency curve computed from counts of silver grains and grain dimensions. The distribution was obtained by counting the grains in strips parallel to spectral lines.

Since the counting of grains along lines or within surfaces should have, especially when measuring small intensities, an extended use not only for different kinds of nebulae, but also for other faint astronomical objects and in the spectroscopy for measurement of intensities in absorption bands, it is of interest to find out in what degree the densities obtained are directly comparable with those obtained by optical photometry. The silver grain itself also stands as a basis for microphotography. I have found this sort of photograph of much interest, especially in cases where either the objects are small or their density is very faint. The counting of grains may also be practically superior to a microphotometry of such objects. The method is, however, rather elaborate, and may be better than photometers only in special cases. In Plates 3—7 I show some microphotographs of the previously mentioned objects for which comparative measurements have been done — NGC 1097, NGC 1365, NGC 4731, NGC 5496 and NGC 5861 — which have been reproduced from the original plates with different enlargements. The effect of the enlargement on the appearance of the silver grains and the structure of the objects is easily seen from the series of photographs. One should also view the great enlargements from some distance.

Before I enter into detail as to the measurements of the objects, I shall give some hints on the theoretical basis for the number of grains as a photometric indicator.

The gradation curve from number of developed silver grains.

On enlargements which come to be used in microphotography, the developed silver grain, the least photographic unit of blackening, can easily be detected and distinguished from adjacent grains, provided that the density is not too great. Especially for the theory of photographic emulsions, the counting of grains (either single or connected with a measurement of the grain size) has become an important photometric indicator. The number of grains precipitated within a certain surface also gives, as was probably first shown by THE SVEDBERG,³ a gradation curve of similar form to that obtained by measurements of optical densities. S. E. SHEPPARD and C. E. K. MEES⁴ and to a greater extent especially E. P. WIGHTMAN, A. P. H. TRIVELLI and S. E. SHEPPARD,⁵ have made statistical investigations on the distribution of the number of grains in emulsions. Since

¹ AN 198 (1914) p. 403.

² PASP 41 (1929) p. 40.

³ Zeitschr f Photogr 20 (1920—21) p. 36.

⁴ Investigations etc. p. 69.

⁵ Kodak Ber 3: 103 (1920); Journ Phys Chem 25 (1921) p. 181 and other papers in the same series in 1921—23.

in the commercial emulsions the grains will lie too close to be easily counted, so called single layer emulsions have been used, obtained by diluting the ordinary emulsion with gelatine 20 to 40 times. In Chap. III when investigating qualities of the photographic plate a thin emulsion (Ilford Thin Film Half Tone), without being a real single layer emulsion, was also included. Measurements of single layer emulsions have shown that there exist plates with relatively uniform grains, but also such where the size of the grains is very heterogeneous (generally highly sensitized emulsions). Although the plates of diluted emulsions are not quite equivalent to normally concentrated ones, yet they are of much interest. In the following I give from available series of observations a comparison between optical density and number of grains. For the sake of completeness I also include the third indicator, the weight of the developed silver, although it will scarcely have any use in practical photometry.

If different kinds of photometry are directly comparable, there must be for the same intensities of light a constant ratio between corresponding points of the gradation curves measured on the same plates, or occur a variation in a known way. If D = optical density, g = weight of silver for unit surface and n = number of grains for unit surface, then D/g and D/n define the »covering power». As a rule a mean value is given for a whole gradation curve. Investigations by SHEPPARD and MEES,¹ and later on by SHEPPARD and H. A. BALLARD² show that there is a great variation in the covering power, dependent on the emulsion, the developer, the time of development etc, and also on the source of light, even if the absorbed energy is unchanged. For an emulsion with uniform grains SHEPPARD and BALLARD found that the covering power is constant, but for one with non-uniform grains it was found to vary considerably.

To investigate D/g and D/n for a rapid emulsion with fairly coarse grains — most emulsions used in astronomical photography are of this type — and a slow emulsion, I have used data obtained by H. SCHEFFERS³ and W. MEIDINGER⁴ with intensity of light in absolute properties for the emulsions Agfa Spezial and Agfa Phototechnisch A, but not used by them for the same purpose. SCHEFFERS gives D and g for the normally concentrated emulsions (l. c., Tab. on p. 120 and 122) developed in Rodinal 1/20 during 3 and 5 minutes respectively. His tabulated values were smoothed by curves and read for corresponding exposures (incident energy of light in absolute measure), which gave D/g . From the series of D/g it is seen that the weight curve and the photometric curve agree very well, and with a suitable choice of scale can be brought almost to coincide. Only some smaller deviations exist in the under-exposed regions and in the solarisation regions of the curves. The great constancy of the ratios D/g is best seen from the following means computed by me:

Agfa Phototechnisch A emulsion. Developed 3 min. $D/g = 0.83 \pm 0.02$ ($n = 12$)				
»	Spezial	»	3	» $D/g = 0.86 \pm 0.03$ ($n = 18$)
»	»	»	5	» $D/g = 0.82 \pm 0.03$ ($n = 17$)

As seen, the value of D/g is fairly unchanged, or only little changed, for the development time, as well as from the Agfa Spezial plate to the Agfa Phototechnisch A plate. The ratios were in all cases without any run.

An appearance somewhat different from that of the weight curve is shown by the curve obtained from counting the number of grains. From SCHEFFERS' measurements it is doubtful if there exists for the curve

¹ Investigations etc. p. 38.

² Journ Frankl Inst (1928) p. 205 and 659.

³ Zeitschr f Physik 20 (1923) p. 109.

⁴ Zeitschr f Physikal Chemie 114 (1925) p. 89.

of grain numbers any under-exposed part, in its beginning also the curve is very nearly a straight line. In fact, the grain curve appears for a very long part to be a straight line, that is, the number of grains increases proportionally to the logarithm of the exposure. Such a curve is very suitable for photometrical purposes. This long straight line portion is not to be ascribed to the less thickness of the emulsion, which might be suspected, since G. EBERHARD,¹ who compared emulsions of unequal thickness, found the photometrical gradation for thick emulsions to have the longer straight-line part. According to H. KLAUDER and H. SIEDENTOPF² thin emulsions show less veil but undiminished sensitivity for low densities as compared with emulsions of normal thickness. Thus such emulsions ought to be very useful for nebular photography.

In the region of solarisation there is for the grain curve another marked difference from the density-curve: the curve obtained from number of grains falls only very little. This same form appears from two curves, obtained from Agfa Spezial emulsions in dilution of 1/18 (MEIDINGER³) and 1/20 (SCHEFFERS⁴) of the normal one. Since the treatment of the emulsions with exposure and development was the same, we have reason to expect that the first curve shall lie higher than the second one, which is also the case. The mean ratio between corresponding points of the curves is

$$\frac{n_{1/18}}{n_{1/20}} = 1.05 \pm 0.02 \quad (n = 22)$$

This will not correspond to inverse proportionality between the number of grains and the degree of dilution. It is true that J. EGGERT and F. LUFT⁵ found that at least within certain limits (and with α -rays) the inverse proportionality with dilution was valid. For the two above-mentioned curves such a result was not found, and the result by EGGERT and LUFT cannot be generalized. Also the ratio was not constant all over the curves, which intersected for very faint exposures. This fact might however be explained as caused for example by such an unavoidable difference in the treatment of the exposed emulsions as difference in temperature of the developers.

If we suppose that, at least approximately, inverse proportionality or a constant ratio between the grain numbers for different dilutions is valid, and compare optical photometric results for a normal emulsion with number of grains of a diluted emulsion, we arrive at the following conclusions. First D/n is rather constant, corresponding to the under-exposed part of the photometric curve. Then it increases very rapidly but appears to be constant again in the beginning of the over-exposed part, and then it diminishes again.

Counts of developed silver grains on anagalactic objects.

The counting of grains on nebular images executed here was made on paper copies of microscopic enlargements from the Helwan original plates. The enlargements varied between 40 and 150 times. First the paper copies were supplied with a squared net, the squares having a side of 3 mm. Only in one case, that of NGC 5861, which was enlarged only 40 times, the side was 2 mm.

¹ Potsdam Publ 26 (1926) p. 1 etc.

² AN 256 (1935) p. 173.

³ L. c., p. 109.

⁴ L. c., p. 122.

⁵ BODENSTEIN Festband = Zeitschr f physikal Chemie Erg.-Bd. (1931) p. 745.

In counting silver grains we have to consider that even for modest exposures not all grains appear separated from each other, but here and there flock together in groups. For every such group an estimate was made as to the number of individual grains the group may be considered to consist of. In such a manipulation, after some training, a certain mean size of grain is accepted by the observer. The number of clustered grains in the actual counts for the measured anagalactic objects in most cases was below 10. Only in the exceptional case that stars also entered the field did the groups show a considerably greater number of grains. For such cases, of course, only approximate numbers can be given, if any at all. As was found for NGC 5861, the fairly poor magnification of 40 times was sufficient for distinguishing the grains. The magnification needed naturally depends on the size of the grains. A counting can also be performed with a certain size of a flock of grains as a unit, and this is probably a method as good as the looking for the grains one by one.

Another difficulty lies in the fact that the grains appear only approximately in the same layer of the emulsion, which has the effect that some grains are seen diffused and that others are probably completely lost. But a close examination of microphotographs taken with high magnification and only in the densest layer of the silver deposit showed no deviations from photographs taken with lower magnification and with a sharpness extending over all layers of silver grains. Thus, at least when regarding only the appearance of objects, this inequality of the foci seems even for very high magnifications to have no influence on the results.

The drawing of the »isophotes», or »isonumbers», as they more properly might be named here, has been performed in a way completely corresponding to that used when figuring microphotometric measurements, except that now the numbers of grains replace the deviations on the photometers or their equivalents.

A necessary condition for a photometry based on counts of grains is that the negatives are not too dense. Moreover, to a certain degree it could in fact be said that the thinner a negative, the easier and more perfect the counts will be.

Thus for example NGC 1097, illustrated here also in microphotographic reproduction, must be considered as too dense for a good count, but the other four objects microphotographed were very suitable.

A practical procedure of value would be that the square net could be transferred directly on the plate, which might be superior in exactitude to constructing nets on paper copies. But otherwise the use of plates instead of paper copies is indifferent, even if the gradation should happen to change. When working out the method I preferred the use of paper copies as being very convenient. On the copies the squares have been accurately drawn by a sharp pencil or a special pen.

Still more preferable from the point of view of exactness would be the arrangement to have the microscope supplied with a squared ocular scale and to make direct measurements on the original plates. Such scales have already been used for investigating grain numbers in purely photographic science, but so far as I am aware not in astronomical photometry.

Since it was considered of importance to see how different observers estimate the numbers of grains, some comparative measurements have been done. The same observer has also repeated his measurements of a certain object on occasions after some time, and comparisons were made between the grain numbers. Some results of these investigations into what may be called »personal equations» appear in Tables 24 and 25.

The series of grain numbers correspond very well. The counted numbers have been taken together into

Table 24. *A comparison between two counts of grains for NGC 5496 by same observer (M. PERSSON).*

Number of grains (n) per square lying between:	$0 \leq n < 50$	$50 \leq n < 75$	$75 \leq n < 100$	$n \geq 100$
Number of squares in group ..	175	323	94	16
Mean of differences between corresponding squares	+ 1.9	+ 2.4	+ 3.2	+ 2.8
Average deviation between corresponding squares	4.2	4.7	6.4	5.7

Table 25. *A comparison between counts of grains for NGC 5496 by two different observers (B. SVENONIUS and I. LUND).*

Number of grains (n) per square lying between:	$0 \leq n < 50$	$50 \leq n < 75$	$75 \leq n < 100$	$n \geq 100$
Number of squares in group ..	197	254	68	21
Mean of differences between corresponding squares	+ 0.03	+ 2.0	+ 11.6	+ 17.7
Average deviation between corresponding squares	4.7	11.3	12.1	15.3

four groups separated by the figures 50, 75 and 100. In doubtful cases the mean value of the numbers of the two corresponding squares have determined to which group they should be counted. The mean differences between number of grains in corresponding squares, giving the systematic, as well as the average deviation of corresponding grain numbers have been computed. Especially in the table from the same observer (counts by Miss PERSSON) the agreement is very good. In fact, the counting of grains can be considered as rather an objective than a subjective method.

There were also made comparisons between measurements on two different copies of the same plate, the copies being exposed somewhat unequally, so that one of them was darker than the other. The darker was shown to give somewhat higher numbers, but »isonumbers» drawn for both gave corresponding contours. When copying, grains can of course be lost, but the structure will remain unchanged and the conclusions of the qualities considered here thus hold.

Lastly I wish to stop a moment at the untenable result gained by KREBS and mentioned above, viz. that a variation in intensity had taken place in NGC 6720. His supposition was based on the fact that when measuring the number of grains, among other things on an enlargement on paper from a photograph of the nebula taken by G. W. RITCHEY, he obtained a ratio about double that obtained from an original plate taken by M. WOLF. KREBS says: »An der Expositionszeit kann also diese Verstärkung der lichtstärkeren Partien rela-

tiv zu den lichtschwächeren nicht liegen, da verlängerte Exposition eigentlich das Gegenteil erwarten lässt: eine relative Verstärkung der lichtschwächeren Partien». — The main objection against this opinion is that the gradation of the negative taken by RITCHEY may very well have been the steeper. The difference in instrument — that used by RITCHEY being the larger one — may also have had the same effect. If the ratio between the densities obtained for two unequal bright points changes with the exposure time, this must be because the four points do not all lie on the straight portion of the gradation curve. A prolonged exposure brings reinforcement of a brighter part of an object only if one of the four points lies on the straight-line part of the curve and the others on its under-exposed part.

CHAPTER X.

SOME SYSTEMATICAL ERRORS OF PERSONAL CHARACTER AND THE MEAN ERROR ENTERING INTO THE ESTIMATION OF TOTAL MAGNITUDE OF ANAGALACTIC OBJECTS, WHEN COMPARED WITH STARS OR MUTUALLY COMPARED.

When the total magnitude of an anagalactic object is determined from a photographic plate this can be done in the following three ways which can be used either single or combined:

A. The total impression of the object is equalled with that of a single star. The surface intensity of the stellar image is then of course generally much higher than that of any portion of the nebular object.

B. The anagalactic object is compared with several stellar images, each one of a density answering to the surface density of a certain portion of the object. It might be that only one star and of the same magnitude as the limiting magnitude of the plate is used, but also a series of stars of different magnitude might be used.

C. The anagalactic object of which the magnitude is to be determined can be compared with other anagalactic objects on the plate. The object (or objects) to be compared with might be known with regard to magnitude, but it might also be unknown, in which case only relative magnitudes are obtained. If one of them is determined, also the others will be known. An eventual systematic to stellar magnitudes will take regard to all the anagalactic objects on the plate.

Already in 1876 and later on in 1900 E. C. PICKERING¹ discussed the difficulty of determining total magnitudes of nebulae, and he devised special photometers for that purpose. PICKERING might have been the first to determine total magnitudes by comparing the nebulae with single out-of-focus stars or by dividing the nebular images in portions, each one comparable in magnitude with a single star.

In the following chapter an investigation will be done on the errors of personal character which enter in such determinations as above, when the comparisons are done only by the naked eye. What will be had is firstly the mean error in one single estimation and secondly eventual systematics which of course might exist in estimations like these. This investigation thus does not enter upon the magnitude of the stars to be compared with. The error arising in stellar magnitudes determined by star counts, the method used also in this paper, has been investigated by SEYFERT.²

¹ Amer Journ of Science 111 (1876) p. 482 and Harvard Ann 33 (1900) p. 136.

² Unpublished paper. Compare p. 84.

According to my opinion the personal errors must deal partly with the error in surface and partly with the error in density, and the work of the present chapter also follows this idea. B and C, answering to parts B and C of the present chapter, thus deal with the errors in surface only, and part D takes regard to the errors in density only. Afterwards the errors have been summed up. Part A takes regard to visual observations, but it is to be expected that the corresponding errors when dealing with photographic images are of the same order of size.

A. ON THE ERROR IN COMPARING AN ANAGALACTIC OBJECT WITH A SINGLE STAR OF AN INTENSITY DIFFERENT FROM THAT OF THE OBJECT.

In the following we consider the error that is produced when an extended, diffuse object (an anagalactic object or a star cluster) is compared with regard to total magnitude with a point-like source of light, such as a star at a sufficient high altitude above the horizon. Thus we deal with visual estimation of equality between a small bright surface and a large, but, according to surface intensity, faint one. On an earlier occasion I have together with Prof. LUNDMARK¹ treated this subject in short, and the results will be given here with some extensions.

In the visual estimation of extinction coefficients performed in Chapter I, a systematical error in the estimated magnitude of stars situated at a low altitude was shown to exist. This error was probably caused from the observer being apt to underestimate the intensity (magnitude) of an object situated at such a low altitude that by the atmospherical halo its image has been extended to a diffuse surface. The effect appeared in Table 5 (p. 21), giving the relation between the apparent magnitude in the moment of observation of the two stars compared and the algebraic mean of the deviations of the estimated magnitudes (extinctions) to the mean magnitudes. From this table it is seen that in the mean deviations positive values are more frequent for the brightest magnitudes. The same effect is found for faint magnitudes, and can be traced back to quite the same cause also here; in both cases the comparison is made between a diffuse object and a point-like one. In the mentioned paper the effect was called by us in Swedish »*yteffekten*» (the surface effect). It must stand in relation to the altitude of the lower star in such a way that it is greater for lower altitudes; but in a relation between the algebraic mean deviation and the altitude, it cannot of course appear, because the extinction curve is drawn to fit the observations. As no regard was taken to the effect discussed here in the computation of extinction coefficients, it may thus be expected that the mentioned curves are slightly erroneously drawn in the sense that they give too high an extinction for the lowest altitudes.

A support for our opinion of the existence of a surface effect was given by the observations of a number of »visual pairs», e. g. v^1 and v^2 Cassiopeiae, θ^1 and θ^2 Tauri, τ and ν Aurigae, δ^1 and δ^2 Gruis etc. These pairs were observed at such low altitudes that the individual components were not seen separated, and their integrated magnitudes were estimated by comparisons with single stars.

From Table 5 and from the observations of pairs of stars, the latter also being observed by me at Helwan, an approximate value of the effect was found. It amounted to about $+ 0^m.3$ for stars standing very near

¹ Nord Astr Tidsskr 16 (1935) p. 142.

the horizon and $+0^m.2$ for visual pairs with components of about equal magnitude. As the dispersion of the individual values is considerable in both cases, and as the effect also with regard to double objects is dependent on the distance between the components, we considered $+0^m.25$ as the probable magnitude of the effect from the mentioned observations.

The existence of a surface effect ought to be still more prominent in the estimation of total magnitudes of anagalactic objects (and clusters), based on comparisons with stars, as has been made by several observers: visually e. g. by J. HOLETSCHEK,¹ K. LUNDMARK² and W. E. BERNHEIMER.³ In an earlier paper LUNDMARK⁴ has also mentioned the existence of a *surface and structure effect*, without discussing it in detail. As comparisons between a galaxy (e. g. the Andromeda nebula) and stars give mutually very conformable results, at least in the hand of a clever observer, the method must be good; but the possibility still exists that the observations may not be free from the mentioned systematical error, of which the sign and magnitude must then be determined. A series by LUNDMARK of 25 estimations of total magnitude of the Andromeda nebula, distributed on seven nights of observation, showed a mean error of $\pm 0^m.15$, which is not higher than is generally found when comparing stars purely visually.

The existence and magnitude of a systematical error of the mentioned kind, entering into estimations and having the character of a personal equation, was shown by comparisons of magnitude series given by different observers. For 12 elliptical NGC-objects, listed by LUNDMARK⁵ in the same paper, and estimated by HOLETSCHEK and by J. G. HAGEN, the mean difference is:

$$\overline{m_{\text{Hagen}} - m_{\text{Holetschek}}} = +0^m.49 \pm 0^m.10$$

To eliminate a possible surface effect we have made use of the good chance that the nebula or cluster can be compared with a small group of stars or a double object at so low an altitude that its components appear as a single, diffuse image. For example, the Pleiades, standing near the horizon, both regarding surface extension and brightness distribution appear very similar to the Andromeda nebula. For the estimation the Pleiades are watched when rising, and the local sidereal time is determined when the star group may be put equal to the Andromeda nebula. From the coordinates of the objects and the sidereal time the altitudes are computed, which are needed for finding extinction differences.

The method can not of course be used as a general method, as difficulties exist in finding suitable star groups for the comparisons. The nebula (or cluster) and the star group must also stand not too far from each other if the comparison is to be accurate.

In Table 26 are given the results of some estimations of »surface objects» made at Lund Observatory by different observers, forming an extension of a list in the previously mentioned paper.⁶ In the former list an error had entered for the magnitude of α Cassiopeia; this has been corrected in the present table.

The table shows that for these observers is found a marked tendency to underestimate the brightness of the diffuse objects. The number of observations is regretfully enough not great. The amount of the surface effect may probably be less with knowledge of it and trying to escape it when observing, but it is better if possible not to take notice of the effect during the observations, but to eliminate it afterwards.

¹ Wien Ann 20 (1907).

² L. c. Compare p. 84.

³ Lund Circ 5 (1932) p. 3 and 6 (1932) p. 1.

⁴ Nord Astr Tidsskr 12 (1931) p. 124.

⁵ Nord Astr Tidsskr 12 (1931) p. 123.

⁶ Nord Astr Tidsskr 16 (1935) p. 147—48.

Table 26. *The systematical deviations (the surface effect) in the estimation of total magnitudes of anagalactic objects and star clusters by some observers, and the average deviations before and after correction for systematics.*

Observer	(<i>n</i>)	Average deviation before correction	Systematical deviation	Average deviation after correction
F. BERGLUND	11	± 0.35	$+ 0.35$	± 0.24
B. EKENBERG	17	± 0.35	$+ 0.01$	± 0.35
A. H. SAMAHA	5	± 0.39	$+ 0.38$	± 0.24
B. SVENONIUS	29	± 0.36	$+ 0.20$	± 0.30
All	62	± 0.35	$+ 0.19$	± 0.30

It is clear that a previous knowledge or imagination of the magnitudes of the objects to be observed can exercise influence on the results. The same is the case with estimations of photographic magnitudes of anagalactic objects, or of visual or photographic magnitudes of objects of any kind. It is therefore of importance that objects are chosen, the magnitudes of which are not kept in mind, or if that is not possible, that several observers without special knowledge about the magnitudes of the objects take part in the estimations. This of course means a greater dispersion in the results, but on the other hand the effect of a previous knowledge of magnitudes will be eliminated.

There must certainly exist differences in observing by the naked eye and by telescopic means. It resulted from our observations that a diffuse object appeared fainter as compared with stars, when observing by telescopic means. In a number of observations performed with the aid of a small eyepiece, the difference in total magnitude was found to amount to one or two tenths of a magnitude. A detailed examination of the influence of the optical properties of the eyepiece (above all diameter and focal length) when estimating total magnitudes would be of interest. In observing by telescopic means, the out-of-focus observation of the star is a mean to make the stellar image diffused, which makes it more nebula-like and at least partly counterbalances the surface effect.

The comparison of a nebula or a cluster with a star group, situated at a low altitude, will especially provide good knowledge of the actual atmospherical extinction. It is most easy only to accept a mean value of the extinction coefficient, but it is better that the observer at the same time determines the extinction coefficient. This can be done according to the method given in Chap. I. At the same time, however, at least to some extent just the systematical error is introduced that we wanted to prevent. But if a very clear night is chosen this error will be reduced to a minimum. In every case it ought not to amount to the same magnitude, as when the comparison dealt with a star and a much extended anagalactic object.

An example of the computation of a total magnitude was given by us as follows. At Helwan (latitude $+ 30^\circ$) September 3rd 1934 at L.S.T. 20^h57^m0 equality in magnitude was observed between the Pleiades and the Andromeda nebula. For the Pleiades at this moment the mean altitude was $2^\circ25'$ and for the nebula 45° . By comparisons of stars at the same time the extinctions for these altitudes were found to be 3^m36 and 0^m08 . The integrated magnitude of the Pleiades, obtained by adding the brightness of a series consisting of the

25 brightest stars of the cluster, is 1^m50 . — For a magnitude obtained in such a way we used the name »seriemagnitud» (series magnitude). — Hence follows for the Andromeda nebula the integrated magnitude 4^m8 , being in close accordance with the value 4^m85 found by LUNDMARK, which also lies far below the value 5^m3 that is generally given to the nebula. The present writer and LUNDMARK are of the opinion that the Andromeda nebula has a magnitude considerably brighter than 5^m3 . Numerous (unpublished) estimates by K. LUNDMARK give a total magnitude of 1^m6 to the Pleiades.

The systematical error discussed here for visual observations must of course also be present when estimations of total magnitudes are made on photographic plates, when a more or less extensive anagalactic object is compared with a single star; the latter being not of the same density as the nebular object.

Other possibilities of the existence of systematic errors of personal character like the surface effect for visual observations also lies in the colour equation; the colour index of anagalactic objects, being on an average $+0^m6$. A good agreement between photographic and visual determinations of total magnitudes, obtained by LUNDMARK and HOLETSCHEK respectively, was found by LUNDMARK¹ as follows:

$$\overline{m_{\text{Lundmark}} - m_{\text{Holetschek}}} = +0^m6$$

As is well-known, e. g. from LUNDMARK'S, SHAPLEY-AMES'² and BERNHEIMER'S³ work, there is otherwise generally to be found great deviations between photographic and visual determinations of nebular magnitudes.

Surface effects of a nature as is described here may also contribute to the systematical deviations found.

In addition it must also be mentioned that the surface effect cannot be completely eliminated by photometric measurements, because also here the extension and the structure of the images contribute to the result.

B. THE SURFACE ERROR IN COMPARING AN OBJECT WITH ONE OR SEVERAL OBJECTS (STARS OR ANAGALACTIC OBJECTS) OF THE SAME INTENSITY AS THE OBJECT TO BE ESTIMATED.

The second method of determining an integrated magnitude is this: it is estimated how many times a limiting magnitude star or other stars, suitably chosen according to intensity, are contained in the surface of the anagalactic object in question. Here, the intensity of the comparison stars chosen may wholly or partly deviate from the intensity of the parts of the object compared with, and also, the estimation of the surface of the anagalactic object from a number of stellar images (or eventually nebular images) implies a certain error. The probable amount of the latter error will be examined in this paragraph with the help of comparisons of different kinds of geometrical figures, cut from white paper and of carefully measured size. They form artificial »anagalactic objects» and »stars». The least surfaces amounted to about 100 mm^2 and the largest to about 2500 mm^2 , the distribution of units being uniform.

The different types of figures made use of are circles, ellipses, squares and irregular nebula-like figures. Squares have been included for the purpose of supplementing the types of figures, although they may

¹ Upsala Medd 21 (1927).

² Harvard Ann 88:2 (1932) p. 70.

³ L. c.

Table 27. *The surface error in the estimation of total surfaces (integrated magnitudes), given in per cent of the surface estimated. Systematical deviation (upper line), and dispersions and number of estimates (lower line) for four observers. Large surface mentioned before small surface.*

Observer	I. HEDBERG	G. LILJEQUIST	S. SUNNER	B. SVENONIUS I	B. SVENONIUS II
Results	$m \pm \varepsilon(m)$	$m \pm \varepsilon(m)$	$m \pm \varepsilon(m)$	$m \pm \varepsilon(m)$	$m \pm \varepsilon(m)$
Surfaces compared	σ n	σ n	σ n	σ n	σ n
Circles compared with circles	$+11.8 \pm 1.9$ 26.6 (206)	$+2.5 \pm 0.9$ 13.3 (203)	-1.1 ± 0.9 12.5 (200)	$+28.5 \pm 1.7$ 25.3 (201)	$+3.3 \pm 0.9$ 13.0 (195)
Ellipses compared with circles	$+10.0 \pm 1.3$ 18.9 (203)	$+9.4 \pm 1.6$ 23.6 (230)	-7.9 ± 1.1 15.5 (200)	$+13.1 \pm 1.3$ 18.0 (203)	$+4.7 \pm 0.6$ 8.4 (183)
Ellipses compared with ellipses	$+7.0 \pm 0.7$ 10.5 (202)	$+12.7 \pm 1.5$ 19.9 (185)	-6.3 ± 0.6 8.7 (202)	-10.2 ± 0.7 9.3 (204)	-3.0 ± 0.8 10.4 (186)
Squares compared with squares	-1.4 ± 0.5 7.0 (197)	-2.2 ± 0.6 9.5 (220)	-9.0 ± 0.7 9.2 (197)	$+1.9 \pm 0.9$ 12.8 (211)	-0.0 ± 0.9 12.3 (204)
Squares compared with circles	$+0.5 \pm 0.7$ 10.3 (200)	-1.2 ± 0.9 11.8 (181)	-1.7 ± 0.9 12.1 (200)	$+5.2 \pm 0.9$ 12.0 (196)	$+4.1 \pm 1.2$ 16.8 (184)
Irregular nebula-like figures compared with circles	-3.3 ± 0.7 9.9 (196)	-11.4 ± 0.9 13.1 (197)	-9.0 ± 1.0 13.9 (196)	-17.8 ± 0.8 11.4 (215)	-7.3 ± 1.2 13.6 (190)

scarcely be said to be represented among real anagalactic objects. In Table 27 the estimations are contained, which have been made besides the author by three other persons. Every observer, except the author, has made about 1200 estimations distributed over 6 series, each one containing about 200 estimations. The number 200 has been considered as quite enough for possible systematics to appear with sufficient accuracy. Every estimation was made quite analogously to the way in which total magnitudes of anagalactic objects, on a plate, are estimated. Thus for example an ellipse (the object) and a small circle (the star) were placed beside each other, and the consideration was made how many times the surface of the circle was contained in the surface of the ellipse. Suppose that the circle, of which the surface is y , was considered to be contained n times in the ellipse, of which the real surface is Y . The total surface obtained by the estimation (Y') is

$$Y' = n \cdot y$$

The determination of the real size (Y) was made for the large, regular figures by measuring diameters or bordering lines by the help of a good ruler. The exactness of the measurements was to 0.1 mm. The irregular nebula-like figures were measured with a planimeter. The small comparison surfaces, that were all regular, were measured with a position micrometer. In all cases mean values were taken of a few measures. The resulting exactness was found to lie far below one per cent of the measured surface.

The error (ΔY) in the determination of the surface of a figure, obtained by estimation, is in per cents of the real surface

$$\Delta Y = \frac{100 (Y' - Y)}{Y}$$

Within every series of 200 estimates the mean has been formed for the percentage obtained from this equation. This mean, besides its mean error, is put in the upper line in every square of the mentioned table. In the lower line the dispersion of the individual observations around the mean value and also the number of estimates in the series are given. In the table, large surfaces are mentioned before small surfaces.

Some conclusions may be drawn. Prominent systematics (over- or under-estimation) is seen to exist, with exception of the two series where squares have been determined, from squares and circles respectively, which series are exceptionally free from any trace of systematics. In the other cases the mean errors of the means are generally small in comparison with the means themselves. It is further obvious that one observer, S. SUNNER, has all his means negative, while the other observers for the three first series, with one exception only, have positive means, and for the last series negative means. Thus all observers in the determination of the surfaces of the irregular, nebula-like figures have made an under-estimation of these.

The first conclusion drawn from the table thus is that errors of a systematical character exist. With the exception of two cases they are limited to about 10 % of the surface estimated. This figure corresponds for a real object to a difference in magnitude of 0^m.11. The weighted average deviations for the different observers' total series amounted to the values given in Table 28.

Table 28.

Observer	Average of systematical errors
I. HEDBERG	5.7 %
G. LILJEQUIST	6.6 »
S. SUNNER	5.8 »
B. SVENONIUS I	12.8 »
» II	3.7 »
Mean:	6.9 %

Further, the table gives the dispersion in the estimation of surfaces. This is the mean error found for an observer in one estimate of the surface of an anagalactic object. The weighted averages of the errors found here are given in Table 29.

Table 29.

Observer	Average of mean errors
I. HEDBERG	14.0 %
G. LILJEQUIST	15.3 »
S. SUNNER	12.0 »
B. SVENONIUS I	14.7 »
» II	12.4 »
Mean:	13.7 %

Table. 30. The mean values of the errors in estimating integrated surfaces of different forms, arranged in order of increasing ratio between big and small surfaces compared. Dispersions and number of estimates within each group also given.

Observer	I. HEDBERG				G. LILJEQUIST				S. SUNNER	
	$q \leq 2$		$2 < q \leq 5$		$5 < q \leq 10$		$q > 10$		$q \leq 2$	
	$m \pm \varepsilon(m)$ σ (n)	$m \pm \varepsilon(m)$ σ (n)	$m \pm \varepsilon(m)$ σ (n)	$m \pm \varepsilon(m)$ σ (n)	$m \pm \varepsilon(m)$ σ (n)	$m \pm \varepsilon(m)$ σ (n)	$m \pm \varepsilon(m)$ σ (n)	$m \pm \varepsilon(m)$ σ (n)	$m \pm \varepsilon(m)$ σ (n)	$m \pm \varepsilon(m)$ σ (n)
Results										
Surfaces compared										
Circles compared with circles	-4.3 ± 1.2 11.3 (84)	$+5.2 \pm 1.8$ 14.8 (67)	$+22.3 \pm 4.5$ 20.5 (21)	$+58.3 \pm 3.9$ 22.9 (34)	-3.9 ± 0.8 7.9 (97)	$+1.6 \pm 1.7$ 13.2 (63)	$+18.6 \pm 1.8$ 11.0 (36)	$+17.0 \pm 7.5$ 20.0 (7)	-2.7 ± 1.1 10.2 (93)	$+3.4 \pm 1.7$ 14.2 (74)
Ellipses compared with circles	-3.1 ± 1.3 10.5 (67)	$+3.4 \pm 1.4$ 10.0 (54)	$+18.0 \pm 2.1$ 15.2 (51)	$+36.8 \pm 4.4$ 24.6 (31)	-11.3 ± 1.7 15.7 (83)	$+17.6 \pm 1.8$ 14.0 (59)	$+19.8 \pm 2.4$ 17.7 (55)	$+29.1 \pm 4.4$ 25.1 (33)	$+3.7 \pm 1.4$ 11.8 (69)	-12.8 ± 1.6 13.4 (71)
Ellipses compared with ellipses	-3.1 ± 0.8 6.3 (68)	$+8.2 \pm 0.7$ 5.9 (68)	$+17.0 \pm 1.3$ 8.0 (38)	$+15.3 \pm 1.7$ 8.8 (28)	-3.9 ± 0.9 6.4 (56)	$+8.9 \pm 1.4$ 11.4 (62)	$+18.6 \pm 2.9$ 16.5 (33)	$+40.9 \pm 3.5$ 20.3 (34)	-5.4 ± 0.8 7.0 (74)	-4.6 ± 1.1 9.5 (76)
Squares compared with squares	-2.2 ± 0.9 5.9 (48)	-1.0 ± 0.8 6.9 (67)	-0.0 ± 1.0 7.3 (51)	-3.5 ± 1.3 7.4 (31)	-3.9 ± 0.9 6.6 (59)	$+0.5 \pm 0.9$ 8.1 (78)	-3.0 ± 1.5 10.2 (49)	-4.5 ± 2.0 11.4 (33)	-4.3 ± 1.0 7.5 (52)	-7.2 ± 1.0 8.6 (67)
Squares compared with circles	-2.0 ± 0.9 8.6 (85)	-0.5 ± 1.1 8.9 (64)	$+2.6 \pm 2.2$ 11.9 (28)	$+9.9 \pm 2.7$ 12.8 (23)	-7.3 ± 1.1 8.8 (60)	-1.7 ± 1.2 9.3 (64)	-1.6 ± 2.0 10.9 (30)	$+14.1 \pm 2.3$ 11.8 (27)	$+4.2 \pm 1.4$ 12.0 (76)	-6.2 ± 1.3 10.8 (68)
Nebula-like figures compared with circles	-7.4 ± 1.6 10.7 (44)	-3.5 ± 1.2 9.0 (57)	-1.5 ± 1.3 9.4 (54)	-0.7 ± 1.7 10.4 (41)	-14.1 ± 1.8 12.4 (47)	-17.3 ± 1.0 8.3 (66)	-11.0 ± 2.1 12.9 (39)	-0.4 ± 2.2 14.5 (45)	-0.6 ± 1.7 10.5 (38)	-9.6 ± 1.5 12.5 (70)

Observer	S. SUNNER				B. SVENONIUS I				B. SVENONIUS II			
	$5 < q \leq 10$		$q > 10$		$q \leq 2$		$2 < q \leq 5$		$q \leq 2$		$2 < q \leq 5$	
	$m \pm \varepsilon(m)$ σ (n)	$m \pm \varepsilon(m)$ σ (n)	$m \pm \varepsilon(m)$ σ (n)	$m \pm \varepsilon(m)$ σ (n)	$m \pm \varepsilon(m)$ σ (n)	$m \pm \varepsilon(m)$ σ (n)	$m \pm \varepsilon(m)$ σ (n)	$m \pm \varepsilon(m)$ σ (n)	$m \pm \varepsilon(m)$ σ (n)	$m \pm \varepsilon(m)$ σ (n)	$m \pm \varepsilon(m)$ σ (n)	$m \pm \varepsilon(m)$ σ (n)
Results												
Surfaces compared												
Circles compared with circles	$+7.4 \pm 2.4$ 13.2 (31)	$+4.5 \pm 9.1$ 12.8 (2)	$+2.5 \pm 2.2$ 17.5 (62)	$+32.8 \pm 1.8$ 14.2 (60)	$+2.5 \pm 2.2$ 17.5 (62)	$+45.2 \pm 3.2$ 19.8 (39)	$+32.8 \pm 1.8$ 14.2 (60)	$+46.1 \pm 3.6$ 22.7 (40)	-6.6 ± 0.6 5.3 (82)	$+12.4 \pm 1.5$ 8.9 (37)	$+4.3 \pm 1.4$ 9.1 (45)	$+17.0 \pm 2.6$ 14.7 (31)
Ellipses compared with circles	-16.0 ± 1.7 11.8 (49)	-13.5 ± 3.5 12.3 (12)	-3.5 ± 1.7 13.0 (61)	$+17.1 \pm 1.8$ 12.3 (47)	-3.5 ± 1.7 13.0 (61)	$+22.2 \pm 2.0$ 15.9 (65)	$+17.1 \pm 1.8$ 12.3 (47)	$+21.5 \pm 2.2$ 12.2 (30)	-7.6 ± 1.1 7.5 (48)	-2.5 ± 1.1 7.9 (50)	-3.6 ± 1.1 9.0 (68)	-7.7 ± 1.1 4.5 (17)
Ellipses compared with ellipses	-11.1 ± 1.6 9.0 (34)	-7.8 ± 2.0 8.4 (18)	-11.6 ± 0.7 6.1 (87)	-8.8 ± 1.2 9.4 (64)	-11.6 ± 0.7 6.1 (87)	-10.6 ± 1.9 12.0 (40)	-8.8 ± 1.2 9.4 (64)	-16.9 ± 2.6 9.4 (13)	-8.5 ± 0.7 5.5 (53)	-2.2 ± 1.7 10.9 (43)	$+2.7 \pm 1.1$ 8.9 (69)	-9.7 ± 1.8 8.4 (21)
Squares compared with squares	-12.9 ± 1.1 7.9 (54)	-15.1 ± 1.7 8.5 (24)	-2.0 ± 1.3 9.1 (49)	-3.7 ± 1.0 9.1 (80)	-2.0 ± 1.3 9.1 (49)	$+2.0 \pm 1.5$ 9.8 (41)	-3.7 ± 1.0 9.1 (80)	$+17.3 \pm 2.1$ 13.5 (41)	-5.5 ± 1.1 8.1 (51)	$+1.8 \pm 1.8$ 11.7 (43)	-2.5 ± 1.4 12.2 (70)	$+9.2 \pm 1.8$ 11.5 (40)
Squares compared with circles	-4.7 ± 1.8 10.2 (34)	-4.2 ± 2.6 12.0 (22)	-2.6 ± 1.0 8.1 (69)	$+5.9 \pm 1.3$ 10.0 (61)	-2.6 ± 1.0 8.1 (69)	$+12.2 \pm 2.0$ 11.9 (37)	$+5.9 \pm 1.3$ 13.4 (29)	$+13.1 \pm 2.5$ 13.4 (29)	-8.0 ± 0.7 5.9 (63)	$+9.2 \pm 2.1$ 11.4 (29)	$+0.2 \pm 1.3$ 9.9 (59)	$+29.1 \pm 3.6$ 20.6 (33)
Nebula-like figures compared with circles	-10.9 ± 1.9 13.7 (50)	-13.7 ± 2.5 15.4 (38)	-20.4 ± 1.1 10.3 (95)	-19.0 ± 1.4 10.4 (54)	-20.4 ± 1.1 10.3 (95)	-15.4 ± 2.0 11.2 (32)	-19.0 ± 1.4 10.4 (54)	-10.0 ± 2.7 15.7 (34)	-16.2 ± 1.1 8.4 (59)	-0.7 ± 2.3 13.5 (35)	-10.0 ± 1.3 10.2 (60)	$+5.4 \pm 2.2$ 12.9 (36)

The error in the mean of course follows the dispersion, because the latter is obtained from the former by the formula

$$\varepsilon(m) = \frac{\sigma}{\sqrt{n}}$$

and n is very near to 200 in all cases.

If a conversion of the different percentages into magnitude differences is wanted, this is easily performed with the tables for integrated magnitudes by W. GYLLENBERG.¹ For these low figures the approximate rule is valid that the number of per cents is the same as the number of hundredths of a magnitude.

To investigate if for an observer the same result is obtained, if the estimations are repeated with knowledge of the error from a previous estimation, the same series were estimated a second time by the writer, as has been seen in the tables. These new estimates were carried out quite routine-like without any comparison with the earlier series when estimations were in progress within a certain series. A comparison with the first set of series shows that the systematical errors in the repeated series are considerably reduced. But besides, in the repeated series the means have kept their signs, with set number 4 as the only exception, which, however, has just passed zero to a small negative figure. It is interesting to see that the estimates of the nebula-like figures still give a rather high negative mean. The mean errors of the means however agree with those obtained before, and so do then of course also the dispersions.

The renewed estimations thus have given the following results: (1) the tendency of systematics has remained, but by a previous knowledge about the earlier obtained errors they can — at least if they are appreciable — be reduced, and (2) the mean error in one single estimate is unchanged.

From the material investigated, the extent to which the error depends on the relative size of the larger surface to the smaller (q) has also been examined. For this purpose the estimates within each series were divided into groups, of which the first group contained cases when the larger surface was no more than 2 times the smaller, the next group cases when the larger surface was more than 2 times but no more than 5 times the smaller surface, the next group when it was between 5 and 10 times, and the last group when it was more than 10 times the smaller surface. The result of this manipulation is seen in Table 30. It is obvious, and there is also reason to expect, that the error shall increase with the relative size of the bigger surface. From this rule, however, nebula-like figures must be omitted which are designated as long and narrow, or as narrow spiral arms separated from each other. For these figures it will in fact be just the same as if they are compared with surfaces of about the same breadth. When for example we let a smaller surface be contained in a spiral arm, we let this procedure be performed by imagining the smaller surface a certain number of times along the spiral arm. Herewith, also, a certain compensation of the errors takes place. As is well seen from the table, the final result, in accordance with this presumption, is that the nebula-like figures give a mean error which is fairly independent of the total surface of the figures.

For the first group ($q \leq 2$) in Table 30, it is prominent that in very nearly all cases the mean is negative. The other groups are in general arithmetically greater, and the table shows clearly how the systematical

¹ Lund Medd II, 87 (1937).

errors grow against positive values. One exception is found: S. SUNNER as a rule has arithmetically decreasing values.

We must put the question:— May estimations of pure geometrical surfaces have any practical importance for correction of total magnitudes obtained for real anagalactic objects? The experiments have, it is true, shown that considerable systematical errors exist. But I think they may scarcely be used for corrections, because it is probable that the systematical error will not remain constant during longer time intervals. The personal disposition when a series of estimations is started must also have a considerable influence on the result.

For continued work on the surface error it would be of interest to compare surfaces of grey or black tones, and also to compare them when the big and the small surface are of a somewhat different tone of grey, a fact answering to what often happens in reality. As said, it is not always possible to get even approximately the same density of the object and the comparison star.

C. ON THE INFLUENCE OF THE GEOMETRICAL FORM IN COMPARING ANAGALACTIC OBJECTS WITH STARS OR ANAGALACTIC OBJECTS WITH EACH OTHER.

The third possibility of estimating the total magnitude of an anagalactic object was to compare it with another object of the same kind. The latter then might be of about the same size, but might also be less or bigger. In the present paragraph we deal with the fact that they are of approximately the same size and also that the mean intensities (densities) are the same.

To examine how a different form of the two objects compared may affect the result, I have made estimates of equality in surface size between surfaces of different forms. In the actual case with astronomical objects on a photographic plate, different round or elliptical objects are mostly dealt with, but also other forms occur. In my experiments only the following purely geometrical figures were used: circles, ellipses, squares and rectangles. The series were as in the previous paragraph cut from white paper, thus marking surfaces of equal intensity. Some of them also were the same as previously. Each series numbered about 35 items. Of the circles two series were prepared. The eccentricity of the ellipses was about 0.8. For the rectangles the ratio of sides was about two.

Although the accuracy in measuring the surfaces of the figures even for the smallest surfaces was below one per cent, the errors of measurement for the small figures in this case may play a certain part in the errors of estimation, which latter are rather small. However, they are supposed to contribute only to the dispersion in the results, and not in a systematical way to the mean values computed.

The estimations were performed in the following way:— Suppose the observer should compare, for example, circles with squares. The series of squares would be placed before him, arranged in order of size. By another person then to the observer would be given the circles, one after another, and he would have to find among the squares one that was of the same area as the circle.

If there was not to be found a square just as large as the circle, the observer had to interpolate its area between two squares. All the series were thus gone through in undetermined order, changing between large

Table 31. *The form effect and the dispersion in comparing different geometrical surfaces by four observers.*

Observer	J. AMUNDSSON	I. HEDBERG	G. LILJEQUIST	B. SVENONIUS
Results	$m \pm \varepsilon(m)$	$m \pm \varepsilon(m)$	$m \pm \varepsilon(m)$	$m \pm \varepsilon(m)$
Surfaces compared	σ n	σ n	σ n	σ n
Circles estimated from circles	— 1.3 ± 0.2 1.4 (36)	+ 0.3 ± 0.4 2.1 (36)	— 0.3 ± 0.5 3.0 (35)	+ 1.5 ± 0.4 2.2 (36)
Circles estimated from squares	— 6.2 ± 1.1 7.4 (42)	+ 8.7 ± 0.8 5.1 (42)	+ 5.4 ± 0.9 5.8 (42)	+ 3.6 ± 0.7 4.3 (42)
Ellipses estimated from circles	+ 12.1 ± 1.3 6.3 (22)	+ 6.3 ± 1.2 5.8 (22)	+ 9.5 ± 1.2 5.8 (22)	— 4.7 ± 0.7 3.2 (22)
Ellipses estimated from squares	+ 10.1 ± 0.7 3.3 (22)	— 2.2 ± 1.8 8.6 (22)	+ 7.3 ± 1.0 4.8 (22)	+ 3.0 ± 0.5 2.5 (22)
Ellipses estimated from rectangles	+ 1.6 ± 1.4 6.4 (22)	+ 0.6 ± 1.7 7.8 (22)	+ 0.3 ± 0.7 3.4 (22)	+ 4.7 ± 0.6 2.9 (22)
Rectangles estimated from circles	+ 0.9 ± 0.7 3.9 (31)	+ 15.7 ± 0.8 4.5 (31)	+ 6.5 ± 1.0 5.6 (31)	— 1.0 ± 0.6 3.5 (31)
Rectangles estimated from squares	+ 2.3 ± 0.9 5.0 (31)	+ 9.1 ± 1.0 5.5 (31)	+ 7.9 ± 1.0 5.3 (30)	— 0.0 ± 0.7 4.0 (31)

and small surfaces. The experiment performed in this way was named: »estimation of circles by help of known squares», or shortly:

circles estimated from squares.

In the computation the difference between the estimated surface and the real size of the circle was given in per cents of the real size. This percentage means the error of estimation. The means of these percentages for all the series have been tabulated in Table 31. The dispersions are also given in the table.

There are some further combinations of types of figures made, as shown in the table, corresponding to all combinations possible of the mentioned figures. Yet they are only performed in so to speak one direction, for example only »unknown circle from known square», and not the reversed.

To get an idea of how carefully a person may be able to compare figures of the same form, the two series of circles were compared.

From the table some conclusions might be drawn:—

Systematical errors exist within the individual series, although of fairly small amounts (about 5 %). In total a systematic exists in the sense that the plus sign occurs more often than does the minus sign.

The existence of a systematical error, is probably due to the influence of the different form of the surfaces compared on the observer's conception of the surfaces. Therefore we have also reason to expect the effect being of a personal character.

In accordance with a »form effect», it stands that for circles compared with circles the dispersion is considerably less than for other comparisons. Here the systematical errors are small (about 1 %).

The estimations performed in different mutual positions show that no very great errors of position exist in the estimations.

The dispersions are of about the same amounts for the different observers as are the systematics. Contributing to the dispersion are the mentioned errors of measurement, but except in comparing circles with circles they are only of little influence. Of greater influence might be that interpolating a surface between two others is difficult. The latter fact may, according to personality, possibly to some extent also contribute to the systematics.

In the experiments it was not possible to state any clear dependence between form effect and size of the surfaces compared. Such an effect seems to depend only on the forms of the figures compared. A possible effect of the position of the surfaces, referred to an eventual major axis, has not been investigated, but can of course also play a part.

Quite in the same way as in the previous paragraph the values of the table, given in per cents of a surface, can be converted into magnitudes, since the light sent from a uniformly luminous, extensive object, is proportional to the surface.

The series here are only provisional, but their nature is not such that much will be gained in extending the number of estimates. It has however its interest to extend as well the number of series as the number of individuals in them, but still more interesting would be only to repeat the estimates after some time. Further, besides the estimation of e. g. circles from squares, there should also be performed the reversed, squares from circles, although in this case it may be expected that the errors as defined above are the same with opposite signs. The comparisons of equal figured surfaces can also be extended to contain other types of figures than only circles. Another part of the problem would be to investigate the influence of the intensity (greyness or blackness, or, with regard to visual observations, possibly color) of the surfaces compared.

D. THE ACCURACY IN THE ESTIMATION OF PHOTOGRAPHIC DENSITIES.

To investigate the accuracy in the comparison of two photographic densities, by means of the naked eye, the plate material made use of in Chapter III B for a determination of spectral sensitivity was used here. One of the plates with the five density bands was considered as »known» with regard to densities and a number of the others as »unknown». For the latter plates an estimation of the densities at the places marked in the spectra on the plate had to be made. This was done by searching out a density on the »known» plate which was considered to be as equal as possible to a certain unknown density. If no photometrically measured density could be found which was considered as just equal with this, an interpolation was made between two suitably chosen densities. After some practice the numerical values of different densities were well kept in mind, but still the measured densities were not quite left when estimating.

Only such plates were chosen for the experiments where no veil of appreciable density was detectable. Together about 1000 estimates were performed, situated within a density interval of $D = 0.01$ to $D = 2.00$ and distributed on two observers.

The error in the estimates could now be computed, because in reality also all the estimated densities

Table 32. *Estimation of photographic densities by two observers, and the corresponding magnitude differences computed for a gradation of the plate of $\gamma = 1$.*

Observer	N. HANSSON			B. SVENONIUS		
Density interval	Number of estimates	Average deviation	Magnitude difference ($\gamma = 1$)	Number of estimates	Average deviation	Magnitude difference ($\gamma = 1$)
0.01—0.10	123	0.02	0 ^m .05	126	0.01	0 ^m .03
0.11—0.30	117	0.04	0.10	118	0.03	0.07
0.31—0.60	107	0.07	0.17	108	0.05	0.12
0.61—1.00	97	0.08	0.20	95	0.06	0.15
1.01—2.00	61	0.10	0.25	61	0.08	0.20

were known from previous photometrical measurements. The error of estimation is seen in Table 32, where the results are grouped in certain density intervals. The errors are given in the form of average deviations.

It is clear from the table that the errors made in the estimation of densities are considerable, as far as we do not deal with very faint densities. The percentage error is fairly constant for not too high densities.

We must thus suppose the density error to be considerable also when we are dealing with densities in anagalactic objects or stellar images. Let us suppose it is of the same amount in both cases and convert the values of the table into magnitude differences.

If we want to give the density differences in magnitude differences, this requires knowledge of the gradation of the plates. The connection between difference in density (ΔD), gradation of the plate (γ) and difference in magnitude (Δm) is easily found to be

$$\Delta m = -2.5 \frac{\Delta D}{\gamma}$$

Let us use the gradation values found in Chap. III B. The extreme values of gradation were $\gamma = 0.5$ and $\gamma = 1.0$; the density in measuring these ranging between $D = 0.10$ and $D = 0.40$. For the Helwan plate material we may count with a mean gamma of $\gamma = 1.0$. This means that the difference in density numerically answers to the difference in the logarithm of the intensity. Then it is also proportional to the difference in magnitude, the factor of proportionality being 2.5 and working in the direction of giving higher magnitude differences, as is given by the equation, where the difference in the logarithm of the intensity is eliminated. If the gradation of the nebular plate had been steeper, we see that the errors would have been less; and if the gradation had been lower, the error would have been greater. If we compare two plates having gamma values of 0.5 and 1.5 respectively, we find that the range in magnitude difference for a constant error of density will vary no less than three times.

Let us now consider the total error in estimation of integrated magnitudes of anagalactic objects, and consider it as composed of a surface error and a density error. If the two components of error are denoted by σ_1 and σ_2 , the total error (σ) is computed from the formula

$$\sigma^2 = \sigma_1^2 + \sigma_2^2$$

We have seen that the surface error as well as the density error are much varying, and we can only count with values which are rather approximative. But they might still be useful to know, as well as the extreme values (biggest and smallest), and in which direction the possibly systematical errors vary for different surfaces and densities.

It seems to be justified to regard the figure 0^m20 as representative for the mean error in one single estimate for the surface as well as for the density. If so, the resulting mean error in one single estimation will be

$$\sigma = 0^m28$$

This is also in agreement with what is found for the internal errors in estimated integrated magnitudes by different observers.

From two different series of integrated magnitudes by the same observer (the writer) it was found in the present paper that an internal error of about 0^m3 should exist. For the comparisons of the Helwan original plates with the diapositives, where no systematics were found to exist, the error was found to be 0^m36 .

The residuals in the SHAPLEY-AMES catalogue indicate a mean error of approximately 0^m2 . From SHAPLEY'S¹ catalogue of 7889 galaxies in Horologium and surrounding regions, a much smaller error comes out (0^m1), but this has its explanation in the fact that the estimates are only made to halves of magnitudes and that the second estimate generally duplicates the first. SHAPLEY, however, considers that the integrated magnitudes of galaxies fainter than the fifteenth magnitude can be estimated on the long exposure Bruce plates with an uncertainty of no more than one or two tenths of a magnitude.

In the extensive unpublished paper by C. K. SEYFERT a mean error of only 0^m14 was found.

A value more likely to be considered as answering to what is generally found is the value in one single observation 0^m26 as found by HOLMBERG.²

If two different observers make estimates of integrated magnitudes on the same plate material we have reason to suspect also considerable systematics between their series to enter. The nature of the systematic and its amount for certain observers has for the surface error been investigated in the present chapter. For the comparison between observations by the present writer and by A. H. SAMAHA a systematic of 0^m23 was found and after correcting for this an average deviation of 0^m49 .

The different problems concerning the form and the density of surfaces, which have been considered as representing anagalactic objects in these estimates, are in no way fully treated here. But my experiments are hoped to serve as a guide for further investigations in this rather unknown region of nebular photometry.

The total or external error is not entered upon by me in the present paper.

In addition, it should also be said that although the errors determined by me are what I would like to call artificial, they were found to agree with errors entering in estimating anagalactic objects. In fact it would not have been surprising if the anagalactic objects had given greater errors, owing to the complicated nature of these intricate but charming stellar systems.

¹ Harvard Ann 88:5 (1935) p. 114.

² L. c., p. 32.

APPENDIX I

VISUAL OBSERVATIONS FOR A COMPUTATION OF EXTINCTION COEFFICIENTS FOR THE HELWAN OBSERVATORY.

The following table contains 350 observations by the writer, and consists of comparisons of stars used for the derivation of extinction coefficients performed in Chapter IB.

In the catalogue follow in order: number, date, local sidereal time, and further name, magnitude, altitude and azimuth of the lower and the higher star. Then some columns follow which have been obtained as results, being the extinction of the higher star (Ext. II), the extinction of the lower star (Ext. I), and the latter's deviation (Δm) from the mean extinction curve for the observation night in question. In the last column are finally given some remarks on the atmospherical conditions prevailing during the observations.

No	Date	L.S.T.	Star I	m_1	Alt.	Az.	Star II	m_2	Alt.	Az.	Ext. II	Ext. I	Δm	Atmospherical conditions
1	Aug. 28th 1934	^h 18 24.7	γ And	^m 2.32	4° 09'	317° 00'	χ Cas	^m 4.41	25° 46'	329° 10'	^m 0.24	^m 2.33	^m + 0.28	Strong haze over the Nile region, but elsewhere very clear. Rather strong WN wind. Steady.
2		18 28.2	"	"	4 45	316 39	δ And	3.49	13 09	297 55	0.59	1.76	+ 0.05	
3		18 32.7	β And	2.27	10 43	304 41	β Peg	2.66	32 06	245 50	0.16	0.55	- 0.05	
4		18 34.7	α PsA	1.57	4 04	231 46	δ Cap	3.18	24 47	230 50	0.25	1.86	- 0.21	
5		18 36.2	γ And	2.32	5 54	315 42	ϵ Cas	3.63	18 48	333 19	0.38	1.69	+ 0.41	
6		18 37.7	α PsA	1.57	4 31	231 20	γ Peg	3.16	13 13	279 42	0.59	2.18	+ 0.36	
7		18 39.7	"	"	4 54	231 05	γ Aql	2.97	65 32	220 41	0.03	1.43	- 0.20	
8		18 41.2	γ And	2.32	6 29	315 19	η Peg	3.22	38 51	246 04	0.11	1.01	- 0.11	
9		18 44.0	α PsA	1.57	5 37	230 30	ϵ Peg	2.68	44 03	253 15	0.08	1.19	- 0.19	
10		18 45.7	γ And	2.32	7 18	314 41	δ Cas	2.99	21 13	327 54	0.33	1.00	+ 0.02	
11		18 48.2	γ Per	3.19	6 38	329 38	ζ Lyr	4.06	82 09	8 45	0.01	0.88	- 0.22	
12		18 55.2	α PsA	1.57	7 29	228 55	β And	2.27	14 43	306 29	0.50	1.20	+ 0.24	
13		18 59.7	α Per	2.08	3 17	327 58	η Per	3.92	11 22	328 59	0.72	2.56	- 0.16	
14		19 01.7	"	"	3 32	327 45	γ Per	3.19	8 12	328 18	0.98	2.09	- 0.39	
15		19 03.7	α PsA	1.57	8 49	227 42	α And	2.39	25 38	289 54	0.24	1.06	+ 0.29	
16		19 06.2	β Tri	3.29	5 41	306 58	π And	4.58	22 06	296 46	0.31	1.60	+ 0.26	
17		19 09.7	α Per	2.08	4 22	325 44	δ Cas	2.99	24 36	326 37	0.25	1.16	- 0.72	
18		19 10.7	α Gru	2.22	3 33	207 52	ι Aqr	4.54	29 44	229 01	0.18	2.50	- 0.02	
19		19 14.7	"	"	3 58	207 16	γ Gru	3.37	13 20	210 44	0.59	1.74	- 0.31	
20		19 20.7	α Per	2.08	5 48	325 44	δ Cyg	3.18	74 16	345 25	0.01	1.11	- 0.20	
21	Sept 1st 1934	18 41.6	α Vir	1.52	3 08	104 22	ζ Vir	3.62	10 42	96 31	0.72	2.82	- 0.18	Very clear, but some haze at the horizon. N wind 19 km/h. Unsteady.
22		18 45.6	α PsA	1.57	5 50	230 19	γ Peg	3.16	14 56	278 46	0.50	2.09	+ 0.79	
23		18 51.4	α UMa	2.07	14 30	25 17	β UMi	2.30	36 40	17 05	0.12	0.35	- 0.02	
24		18 59.6	α Per	2.08	3 18	327 56	π And	4.58	20 20	296 33	0.36	2.86	+ 0.16	
25		19 00.6	"	"	3 22	327 50	γ Per	3.19	8 01	228 29	0.98	2.09	- 0.55	
26		19 05.1	"	"	3 55	327 21	ϵ Cas	3.63	21 37	331 40	0.31	1.86	- 0.32	
27		19 06.1	α PsA	1.57	9 10	227 33	α And	2.39	26 05	289 45	0.24	1.06	+ 0.33	
28		19 11.6	γ UMa	2.72	13 21	34 28	β Cyg	3.08	85 53	242 00	0.00	0.36	- 0.09	
29		19 16.1	γ And	2.32	12 09	311 45	α Peg	2.96	36 17	266 52	0.13	0.77	+ 0.25	
30		19 17.6	α Gru	2.22	4 13	206 53	γ Gru	3.37	13 39	210 12	0.54	1.69	- 0.30	
31		19 21.1	ι Cet	3.76	9 10	253 45	γ Psc	3.97	28 48	255 35	0.20	0.41	- 0.32	
32		19 26.6	α Ari	2.12	3 54	294 31	β Ari	2.96	4 59	290 48	1.66	2.50	+ 0.30	
33		19 37.1	α Per	2.08	7 52	323 57	γ And	2.32	15 35	309 49	0.47	0.71	- 0.19	
34		19 44.1	β Cet	2.30	4 00	246 13	ι Cet	3.76	12 20	251 40	0.63	2.09	- 0.04	
35		19 57.1	α Ari	2.12	10 00	291 05	β Peg	2.66	50 00	278 43	0.06	0.60	- 0.07	
36		19 58.6	β Cet	2.30	6 51	244 16	α Peg	2.96	45 29	260 43	0.08	0.74	- 0.32	
37		20 09.1	η Boo	3.00	5 32	71 40	θ CrB	4.40	31 08	69 00	0.18	1.58	+ 0.18	
38		20 16.8	"	"	3 55	70 40	μ CrB	5.33	33 44	44 41	0.14	2.47	+ 0.29	

No	Date	L.S.T.	Star I	m_1	Alt.	Az.	Star II	m_2	Alt.	Az.	Ext. II	Ext. I	Δm	Atmospherical conditions
		$h \quad m$		m				m			m	m	m	
39		20 23.6	α Boo	0.14	7° 16'	71° 41'	α Aql	1.13	67° 18'	156° 35'	0.02	1.01	+ 0.02	
40		20 27.1	"	"	6 36	71 17	α Cyg	1.55	74 42	351 54	0.01	1.42	+ 0.32	
41		20 32.1	η UMa	2.21	15 20	41 07	γ Dra	2.47	53 52	41 54	0.04	0.30	- 0.03	
42		20 37.6	α Boo	0.14	4 27	69 58	"	"	53 06	42 25	0.04	2.37	+ 0.51	
43		20 41.6	"	"	3 39	69 33	α CrB	2.53	23 14	71 09	0.28	2.67	+ 0.27	
44		20 46.1	"	"	2 45	69 01	ϵ Boo	2.54	12 25	65 25	0.62	3.02	- 0.41	
45		20 49.1	"	"	2 09	68 40	β CrB	3.88	21 10	67 30	0.33	4.07	- 0.10	
46		20 51.6	"	"	1 39	68 20	ψ Boo	4.63	15 08	66 56	0.50	4.99	- 0.95	
47	Sept	18 40.1	α Vir	1.52	3 27	104 35	π Sco	3.20	21 33	140 21	0.29	1.97	+ 0.06	Very clear; day
48	2nd	18 42.6	"	"	2 53	104 14	β CrB	3.88	47 20	77 50	0.07	2.43	+ 0.10	before excellently
49	1934	18 48.6	"	"	1 40	103 33	μ CrB	5.33	49 24	63 20	0.05	3.86	+ 0.19	clear. Not much
50		18 50.6	α Per	2.08	2 14	328 59	κ Cas	4.41	28 35	328 29	0.18	2.51	- 0.42	haze. Wind NNW,
51		18 53.1	"	"	2 24	328 56	δ And	3.78	15 40	317 09	0.45	2.15	- 0.62	at beginning not
52		18 53.3	"	"	2 44	328 30	γ Per	3.19	7 28	328 57	0.94	2.05	- 0.38	very strong, but
53		19 02.1	γ Per	3.19	8 14	328 16	ϵ Cas	3.63	21 22	331 49	0.32	0.76	+ 0.14	increasing to 40
54		19 21.3	α Ari	2.12	2 52	295 10	β Ari	2.96	3 54	291 23	1.68	2.52	+ 0.19	km/h. Fairly
55		19 24.1	α Per	2.08	6 09	325 12	γ Cas	2.48	29 25	325 43	0.18	0.58	- 0.34	steady.
56		19 30.3	α Ari	2.12	4 37	294 09	β Tri	3.29	9 59	304 23	0.54	1.71	+ 0.38	
57		19 39.6	β Cet	2.30	3 08	245 45	ι Cet	3.76	13 01	251 10	0.56	2.02	- 0.11	
58		19 42.6	α Ari	2.12	7 07	292 42	β Peg	2.66	46 53	279 50	0.08	0.62	- 0.12	
59		19 45.1	η Boo	3.00	10 34	74 19	δ Boo	3.60	33 04	67 14	0.15	0.75	+ 0.24	
60		19 49.6	β Gru	2.43	4 01	207 16	κ Sco	2.76	14 38	154 06	0.50	0.83	- 0.77	
61		19 57.6	η Boo	3.00	7 56	72 52	β Ser	3.89	29 10	87 57	0.18	1.07	+ 0.42	
62	Sept	19 41.0	η Boo	3.00	11 25	74 51	δ Boo	3.60	33 52	67 30	0.14	0.74	+ 0.05	Very clear. N
63	3rd	19 46.0	β UMa	2.67	5 39	24 10	λ Dra	3.98	17 11	17 22	0.43	1.74	+ 0.42	wind 24km/h. Fair-
64	1934	19 48.0	γ UMa	2.72	8 42	31 04	γ UMi	3.34	35 21	20 16	0.13	0.75	- 0.11	ly steady.
65		19 53.5	β Gru	2.43	4 28	206 43	ζ Cap	3.92	33 30	203 42	0.15	1.64	- 0.16	
66		20 55.1	α UMa	2.07	5 29	14 05	ι Dra	3.47	28 47	35 31	0.20	1.60	+ 0.22	
67		21 01.1	α Aur	0.33	1 49	324 09	δ Per	3.31	15 52	316 10	0.46	3.44	- 0.17	
68		21 03.1	"	"	2 04	323 57	ϵ Per	3.14	9 59	310 27	0.77	3.58	+ 0.18	
69		21 04.6	"	"	2 13	323 48	γ Per	3.19	24 07	319 04	0.27	3.13	- 0.15	
70		21 07.1	"	"	2 30	323 30	δ Cas	2.99	38 33	324 53	0.11	2.77	- 0.26	
71		21 12.1	"	"	3 15	322 52	α Per	2.08	21 04	316 00	0.33	2.08	- 0.45	
72		21 15.1	α Phe	2.57	5 29	213 41	δ Aqr	3.68	38 30	209 56	0.11	1.22	- 0.16	
73		21 16.6	α Aur	0.33	3 50	322 26	α UMi	2.21	30 11	358 56	0.18	2.06	- 0.11	
74		21 18.1	α UMa	2.07	4 14	11 36	ϵ UMi	4.45	32 45	8 31	0.15	2.53	+ 0.63	
75		21 24.1	α Aur	0.33	4 50	321 30	ϵ PsA	1.57	26 28	201 43	0.23	1.47	- 0.15	
76		21 24.6	α UMa	2.07	3 57	10 52	α Dra	3.84	18 40	25 02	0.40	2.17	+ 0.09	
77		21 27.6	"	"	3 48	10 31	κ Dra	4.08	15 35	14 54	0.48	2.49	+ 0.29	
78		21 30.1	α Aur	0.33	5 42	320 51	α Cyg	1.55	71 47	29 53	0.01	1.23	- 0.07	
79		21 31.6	α UMa	2.07	3 40	10 08	λ Dra	3.98	11 43	9 54	0.67	2.58	+ 0.31	
80	Sept	20 06.2	β Cet	2.30	8 24	243 14	γ Peg	3.16	32 20	269 13	0.16	1.02	+ 0.19	Clear, but hazy
81	11th	20 08.4	δ Cas	2.99	31 11	325 00	δ Cyg	3.18	74 04	16 25	0.01	0.20	+ 0.05	at the horizon.
82	1934	20 12.2	δ Per	3.31	8 49	320 36	κ Cas	4.41	38 00	328 18	0.12	1.22	+ 0.45	Variating strong N
83		20 14.7	η UMa	2.21	17 51	42 28	η Dra	2.96	41 07	32 12	0.10	0.85	+ 0.51	wind (mean 28
84		20 20.2	β Gru	2.43	6 50	202 50	γ Gru	3.37	19 14	198 41	0.38	1.32	+ 0.26	km/h). Rather
85		20 22.2	ζ UMa	2.41	16 13	34 54	β Dra	3.08	51 16	42 08	0.06	0.73	+ 0.34	steady.
86		20 27.7	ϵ Boo	2.54	16 06	67 18	ζ Her	3.13	41 26	72 29	0.10	0.69	+ 0.30	
87		20 31.7	α Ari	2.12	17 05	287 21	β And	2.27	33 07	294 49	0.16	0.31	- 0.05	
88		20 34.9	ϵ Per	3.14	5 25	313 20	κ Per	3.99	15 36	312 46	0.48	1.33	- 0.09	
89		20 38.7	α Boo	0.14	4 21	69 53	α CrB	2.53	23 47	71 30	0.27	2.66	+ 0.74	
90		20 40.2	"	"	3 55	69 42	α Sco	1.35	7 03	125 54	1.13	2.34	+ 0.16	
91		20 43.7	"	"	3 13	69 19	ϵ Boo	2.54	12 56	65 42	0.59	2.99	+ 0.21	
92		20 46.2	"	"	2 44	68 56	β CrB	3.88	21 50	67 47	0.32	4.06	+ 0.68	
93		20 47.7	"	"	2 27	68 50	ρ Boo	3.77	11 08	60 55	0.72	4.35	+ 0.57	
94		20 49.2	"	"	1 20	68 05	η CrB	5.16	20 47	65 52	0.33	5.35	- 0.08	
95		20 52.7	α UMa	2.07	5 30	14 18	γ UMi	3.34	30 33	20 45	0.18	1.45	+ 0.04	
96		21 02.7	α Aur	0.33	2 07	324 00	ν Per	4.02	13 20	311 26	0.59	4.28	+ 0.08	
97		21 06.2	"	"	2 28	323 36	ζ Per	3.12	7 40	302 14	1.05	3.84	+ 0.07	
98		21 07.7	"	"	2 40	323 25	ϵ Per	3.14	10 55	309 55	0.72	3.53	+ 0.03	
99		21 09.7	"	"	2 55	323 10	δ Per	3.31	17 11	315 32	0.44	3.42	+ 0.29	

No	Date	L.S.T.	Star I	m_1	Alt.	Az.	Star II	m_2	Alt.	Az.	Ext. II	Ext. I	Δm	Atmospherical conditions
		<i>h m</i>		<i>m</i>				<i>m</i>			<i>m</i>	<i>m</i>	<i>m</i>	
100		21 11.7	α Aur	0.33	3° 11'	322° 58'	β Ari	2.96	27° 03'	279° 12'	0.22	2.85	+ 0.02	
101		21 14.2	"	"	3 30	322 40	γ And	2.32	32 36	303 12	0.16	2.15	- 0.37	
102		21 16.7	"	"	3 51	322 24	β Cas	2.56	49 27	327 40	0.06	2.29	+ 0.06	
103		21 19.2	"	"	4 26	322 05	α Per	2.08	22 15	315 39	0.31	2.06	+ 0.19	
104		21 28.7	α CrB	2.53	13 38	66 30	η Dra	2.96	32 24	33 09	0.16	0.59	+ 0.17	
105		21 29.7	ζ UMa	2.41	7 38	29 06	γ UMi	3.34	27 16	20 10	0.22	1.15	+ 0.22	
106		21 32.2	β Ari	2.96	31 25	277 04	γ Peg	3.16	50 50	256 21	0.06	0.26	+ 0.11	
107		21 33.7	γ Cet	3.79	13 09	265 50	γ Ari	4.20	31 20	275 04	0.18	0.59	+ 0.13	
108		21 43.7	α Cet	2.85	11 40	267 46	β Tri	3.29	35 25	293 21	0.14	0.58	+ 0.03	
109		21 52.2	ι Aur	2.89	4 48	306 45	ξ Per	4.26	16 29	301 57	0.47	1.84	+ 0.16	
110		21 57.4	η Aur	3.48	8 33	312 58	38 Per	3.99	18 40	296 52	0.39	0.90	+ 0.08	
111		21 59.2	β Aur	2.26	3 08	321 41	δ Aur	3.91	9 20	328 45	0.83	2.48	- 0.42	
112		22 07.2	α Tau	1.08	2 52	287 19	ζ Per	3.12	18 32	296 33	0.41	2.45	- 0.77	
113		22 10.2	"	"	3 29	286 54	α Cet	2.85	17 20	264 19	0.44	2.21	- 0.33	
114		22 12.2	β Aur	2.26	4 57	320 07	ζ Per	3.12	19 28	296 06	0.38	1.24	- 0.38	
115		22 17.4	α Tau	1.08	4 58	286 04	γ And	2.32	44 13	301 10	0.08	1.32	- 0.29	
116		22 19.2	β Aur	2.26	5 52	319 23	δ Per	3.31	28 09	311 09	0.21	1.26	- 0.13	
117		22 20.9	α Tau	1.08	5 40	285 33	β Cet	2.30	31 12	219 22	0.18	1.40	+ 0.04	
118		22 22.7	"	"	5 50	285 30	β And	2.27	67 40	290 35	0.02	1.21	- 0.09	
119	Sept 12th 1934	21 37.1	η UMa	2.21	6 37	35 08	ι Dra	3.47	21 07	33 52	0.36	1.62	+ 0.34	Very clear; not much haze. Some sand dust from the N. N wind 28km/h.
120		21 39.1	α Phe	2.57	8 16	209 08	γ Gru	3.37	22 22	182 22	0.34	1.14	+ 0.12	
121		21 45.9	ϵ UMa	2.03	3 06	21 32	α Dra	3.84	16 50	23 54	0.48	2.29	- 1.21	
122		21 49.1	α CrB	2.53	9 37	64 25	ζ Her	3.13	24 53	66 17	0.30	0.90	+ 0.06	
123		21 56.9	ι Aur	2.89	5 32	305 13	40 Per	5.22	19 35	298 19	0.42	2.75	+ 1.17	
124		21 59.1	ζ UMa	2.41	5 30	26 13	α Dra	3.84	15 42	22 50	0.52	1.95	+ 0.35	
125		22 00.1	ι Aur	2.89	6 08	304 52	ξ Per	4.26	18 10	301 10	0.45	1.82	+ 0.42	
126		22 02.4	α CrB	2.53	7 06	62 51	η Her	3.66	25 15	57 52	0.29	1.42	+ 0.24	
127		22 03.6	ι Aur	2.89	6 44	304 28	38 Per	3.99	19 49	296 20	0.39	1.49	+ 0.22	
128		22 05.1	δ Aur	3.91	9 25	327 24	β Cam	4.24	18 44	329 42	0.42	0.75	- 0.12	
129		22 06.6	β Aur	2.26	4 15	320 49	58 Per	4.41	14 48	309 11	0.56	2.71	+ 0.46	
130		22 15.4	α Tau	1.08	4 32	286 14	ζ Per	3.12	20 04	295 47	0.39	2.43	+ 0.35	
131		22 21.1	"	"	5 46	285 35	α Cet	2.85	19 41	262 52	0.40	2.17	+ 0.67	
132		22 24.4	β Aur	2.26	6 43	318 50	δ Per	3.31	28 23	311 09	0.23	1.28	+ 0.01	
133		22 27.1	α Tau	1.08	7 00	284 54	α Ari	2.12	41 33	275 30	0.10	1.14	- 0.06	
134		22 28.6	"	"	7 05	284 26	β And	2.27	56 38	289 48	0.04	1.23	+ 0.03	
135		22 36.4	β Tau	1.98	4 57	300 11	38 Per	3.99	27 23	294 22	0.24	2.25	+ 0.40	
136		22 39.4	"	"	5 33	299 54	ι Aur	2.89	12 30	301 07	0.72	1.63	+ 0.05	
137		22 43.6	θ Aur	2.90	5 09	310 29	58 Per	4.41	21 10	306 10	0.36	1.87	+ 0.10	
138		22 46.4	β Tau	1.98	6 53	299 10	β Ari	2.96	48 17	267 50	0.07	1.05	- 0.18	
139		22 49.9	"	"	7 32	298 43	β Aur	2.26	10 24	316 16	0.84	1.12	- 0.03	
140		22 51.9	θ Aur	2.90	6 28	309 33	η Aur	3.48	17 28	307 56	0.45	1.03	- 0.29	
141		22 53.1	$\nu + \tau$ Aur	3.63	9 16	310 00	ζ Aur	3.90	18 18	307 22	0.45	0.72	- 0.16	
142		22 55.4	π^8 Ori	3.45	5 23	274 49	30 Tau	5.26	20 44	270 57	0.36	2.17	+ 0.51	
143		22 57.6	γ Eri	3.25	6 16	250 17	δ Cet	4.21	30 26	251 08	0.20	1.16	- 0.21	
144		23 01.9	β Tau	1.98	9 53	297 26	δ Cas	2.99	52 00	332 10	0.06	1.07	+ 0.25	
145		23 07.9	β Aur	2.26	13 10	314 38	"	"	52 37	332 57	0.05	0.78	+ 0.18	
146		23 09.1	$\circ$ UMa	3.54	6 51	341 16	335 Cam	4.94	22 50	338 13	0.32	1.72	+ 0.49	
147		23 14.1	ζ Tau	3.24	6 22	290 46	τ Tau	4.50	18 31	286 12	0.45	1.71	+ 0.37	
148		23 16.4	β Tau	1.98	12 37	295 49	β Cas	2.56	59 53	347 10	0.03	0.61	- 0.02	
149		23 17.9	ζ Tau	3.24	7 05	290 17	ϵ Tau	3.73	16 00	271 16	0.52	1.01	- 0.18	
150		23 19.1	α Oph	2.45	9 01	80 23	ζ Aql	3.26	29 05	90 20	0.21	1.02	+ 0.10	
151		23 24.4	γ Ori	2.01	3 45	275 07	τ Tau	4.50	20 41	285 10	0.39	2.88	+ 0.14	
152		23 26.4	"	"	4 09	274 50	π^8 Ori	3.45	12 06	271 01	0.72	2.16	- 0.16	
153		23 27.4	"	"	4 22	274 44	ζ Tau	3.24	21 31	282 40	0.35	1.58	- 0.59	
154		23 30.9	"	"	5 12	274 13	ζ Per	3.12	35 14	289 40	0.15	1.26	- 0.47	
155		23 40.4	β Eri	3.12	5 56	260 30	ν Eri	4.28	12 40	258 23	0.67	1.83	+ 0.37	
156		23 42.1	β Ori	0.62	2 27	259 00	μ Eri	4.34	11 12	259 27	0.79	4.51	+ 0.01	
157		23 42.8	"	"	2 36	258 53	ν Eri	4.28	13 11	258 02	0.65	4.31	+ 0.04	
158		23 44.1	"	"	2 52	258 46	π^8 Ori	3.45	16 00	268 31	0.52	3.35	- 0.43	
159		23 46.1	"	"	3 16	258 32	γ Eri	3.25	15 51	243 21	0.52	3.15	- 0.12	
160		23 48.1	"	"	3 52	258 15	γ Ori	2.01	8 49	272 10	0.94	2.33	- 0.19	
161		23 49.9	δ Ori	2.66	4 25	267 04	π^2 Ori	4.60	18 00	270 05	0.45	2.39	+ 0.26	
162		23 50.9	β Ori	0.62	4 17	257 53	α Cet	2.85	38 33	248 50	0.12	2.35	+ 0.12	

No	Date	L.S.T.	Star I	m_1	Alt.	Az.	Star II	m_2	Alt.	Az.	Ext. II	Ext. I	Δm	Atmospherical conditions
		<i>h m</i>		<i>m</i>				<i>m</i>			<i>m</i>	<i>m</i>	<i>m</i>	
163		23 55.4	β Ori	0.62	5° 14'	257° 17'	β Tri	3.29	62° 09'	288° 31'	0.03	2.70	+ 0.98	
164		23 56.6	δ Ori	2.66	5 51	266 14	π^b Ori	4.04	15 25	263 45	0.56	1.94	+ 0.46	
165		23 59.4	"	"	6 28	265 51	π^a Ori	3.45	19 16	266 56	0.42	1.21	— 0.11	
166		0 05.6	γ Ori	2.01	13 40	270 02	γ Cas	2.48	58 36	348 50	0.03	0.50	— 0.09	
167		0 06.6	ζ Ori	1.99	5 20	264 40	π^a Ori	3.98	19 55	264 49	0.39	2.38	+ 0.70	
168	Sept	23 22.0	γ Ori	2.01	3 13	275 25	ζ Tau	3.24	7 56	289 52	0.84	2.07	— 0.80	Very clear except low to the North. NNE wind 20 km/h. Fairly unsteady.
169	13th	23 26.5	"	"	4 10	274 51	ι Aur	2.89	22 13	296 28	0.28	1.16	— 0.30	
170	1934	23 53.5	γ Gru	3.37	16 29	154 54	μ Peg	3.75	74 08	109 00	0.01	0.39	+ 0.12	
171		23 58.0	ϵ Gru	3.83	6 52	168 40	ϵ PsA	4.41	29 30	159 24	0.18	0.76	— 0.11	
172		0 02.5	γ Ori	2.01	12 00	270 24	α Ari	2.12	62 16	263 14	0.02	0.13	— 0.31	
173		0 06.0	β Ori	0.62	7 33	255 51	α Tau	1.08	28 04	273 31	0.19	0.65	— 0.12	
174		0 07.0	β Eri	3.12	10 47	257 30	γ Cet	3.79	44 57	240 40	0.07	0.74	+ 0.22	
175		0 13.5	ζ Ori	1.99	6 47	263 47	ζ Per	3.12	44 53	287 13	0.07	1.20	+ 0.33	
176		0 16.7	τ Ori	3.84	9 50	256 04	μ Eri	4.34	18 25	254 42	0.37	0.87	+ 0.30	
177		0 19.5	δ Ori	2.66	10 51	263 16	β Ari	2.96	67 17	251 00	0.01	0.31	— 0.20	
178		0 21.5	κ Ori	2.44	3 00	257 00	τ Ori	3.84	10 53	255 10	0.66	2.06	+ 0.06	
179		0 25.7	γ Gem	2.25	6 25	285 18	ι Aur	2.89	33 54	291 54	0.14	0.78	— 0.15	
180		0 28.5	κ Ori	2.44	4 29	256 08	β Eri	3.12	15 12	254 41	0.46	1.14	— 0.22	
181		0 30.0	α Lep	2.87	3 05	246 58	ι Eri	4.01	16 13	242 10	0.43	1.57	— 0.38	
182		0 31.0	α Gem	1.52	4 23	304 44	θ Aur	2.90	24 08	300 31	0.24	1.62	+ 0.23	
183		0 33.5	α Eri	0.89	1 35	188 10	β Phe	3.57	13 04	185 07	0.54	3.22	— 0.08	
184		0 37.7	α Gem	1.52	5 34	304 00	γ Gem	2.25	8 53	283 52	0.75	1.48	+ 0.38	
185		0 39.5	α Eri	0.89	1 44	187 25	γ Phe	3.49	15 42	188 38	0.43	3.03	— 0.10	
186		0 45.2	β Gem	1.34	3 00	301 08	ϵ Gem	3.22	13 21	291 25	0.54	2.42	+ 0.42	
187		0 47.5	ϵ Lep	3.34	9 24	237 08	δ Eri	3.71	32 30	232 48	0.14	0.51	— 0.09	
188		0 49.7	α Gem	1.52	7 44	302 34	β Aur	2.26	29 53	307 31	0.16	0.90	+ 0.15	
189		0 50.5	β Gem	1.34	3 51	300 28	θ Aur	2.90	27 49	299 02	0.19	1.75	+ 0.17	
190		0 53.7	"	"	4 29	300 08	γ Gem	2.25	12 17	282 04	0.59	1.50	+ 0.13	
191		0 56.2	ζ Lep	3.84	7 37	247 57	π Eri	4.60	31 06	230 55	0.16	0.92	+ 0.16	
192		1 00.2	β Gem	1.34	5 44	299 22	β Tau	1.98	33 40	286 13	0.13	0.77	— 0.30	
193		1 01.5	κ Ori	2.44	11 22	251 45	α Cet	2.85	51 53	232 21	0.04	0.45	— 0.03	
194		1 05.5	α Gru	2.22	2 45	152 09	β Aqr	3.20	26 07	114 14	0.22	1.20	— 0.96	
195		1 10.0	α Eri	0.89	2 25	183 22	θ Eri	3.27	15 44	199 50	0.43	2.81	+ 0.41	
196	Sept	23 42.0	β Ori	0.62	2 28	258 59	β Tau	1.98	17 43	293 19	0.36	1.72	— 0.38	Very clear. To the N and E no haze visible, but at end clouds coming from the N. Wind decreasing; 25—10 km/h. Steady.
197	14th	23 42.5	δ Ori	2.66	2 48	268 00	π^b Ori	4.04	12 24	265 32	0.58	1.96	+ 0.13	
198	1934	23 44.5	α UMa	2.07	2 24	353 50	γ UMi	3.34	18 38	15 20	0.36	1.63	— 0.51	
199		23 46.7	ϵ Ori	2.03	2 37	267 04	β Eri	3.12	6 27	260 15	0.89	1.98	+ 0.02	
200		23 47.5	ζ Ori	2.14	1 12	267 03	η Ori	3.64	4 30	264 31	1.15	2.65	— 1.12	
201		23 52.5	"	"	2 18	266 23	β Eri	3.12	7 41	259 28	0.81	1.79	— 0.44	
202		23 53.0	γ Ori	2.01	9 57	271 13	γ Cas	2.48	57 54	346 04	0.03	0.50	— 0.03	
203		23 54.2	ϵ Ori	2.03	4 00	266 14	ζ Per	3.12	77 54	282 18	0.00	1.09	— 0.21	
204		23 56.0	ϵ Gem	3.22	3 36	297 19	μ Gem	3.13	6 25	292 25	0.89	0.80	— 0.60	
205		0 00.0	α UMa	2.07	2 45	353 00	ζ Dra	3.45	22 08	25 36	0.27	1.65	— 0.22	
206		0 02.5	β Ori	0.62	6 52	256 26	α Aql	1.13	27 02	95 38	0.20	0.71	— 0.09	
207		0 03.7	γ Gem	2.25	1 52	287 59	θ Gem	3.83	8 35	304 39	0.78	2.36	— 0.34	
208		0 05.5	α Eri	0.89	0 31	191 50	δ Phe	4.10	8 50	193 32	0.75	3.96	— 0.94	
209		0 10.7	ϵ Ori	2.03	7 35	264 16	α Cet	2.85	42 30	245 00	0.07	0.89	+ 0.17	
210		0 11.5	γ Gem	2.25	3 30	287 00	μ Gem	3.13	9 30	290 37	0.73	1.61	+ 0.14	
211		0 14.0	α Eri	0.89	0 44	190 44	β Phe	3.57	12 17	188 31	0.58	3.26	— 1.27	
212		0 14.7	κ Ori	2.44	1 35	257 05	τ Ori	3.84	9 22	256 24	0.70	2.10	— 1.03	
213		0 15.0	α Gem	1.52	1 32	306 37	θ Gem	3.83	10 05	303 34	0.70	3.01	— 0.14	
214		0 18.0	ν UMa	4.02	4 36	341 39	ζ UMi	4.53	22 10	10 14	0.27	0.78	— 0.38	
215		0 19.2	κ Ori	2.44	2 32	257 21	η Ori	3.64	11 19	260 29	0.64	1.84	— 0.18	
216		0 20.0	α Gem	1.52	2 24	306 00	ϵ Gem	3.22	8 17	294 25	0.80	2.50	+ 0.33	
217		0 21.2	γ Gem	2.25	5 29	285 50	ι Aur	2.89	33 04	292 06	0.14	0.78	— 0.22	
218		0 23.0	α Lep	2.87	2 05	247 56	θ Aur	2.90	23 03	300 56	0.25	1.63	+ 0.12	
219		0 25.0	α Gem	1.52	3 23	305 27	θ Aur	2.90	23 03	300 56	0.25	1.63	+ 0.12	
220		0 29.0	α Eri	0.89	1 20	188 56	δ Cap	3.18	29 03	133 46	0.17	2.46	— 1.10	
221		0 30.0	α UMa	2.07	3 40	349 40	δ Cas	2.99	58 50	247 29	0.03	0.95	— 0.45	
222		0 32.2	β Lep	3.07	3 10	343 41	ι Eri	4.01	16 26	241 32	0.42	1.36	— 0.24	
223		0 36.5	β Gru	2.43	8 35	160 16	η Peg	3.22	64 50	82 43	0.02	0.81	+ 0.18	
224		0 39.0	β Gem	1.34	1 45	301 48	ϵ Gem	3.22	12 06	292 17	0.58	2.46	— 0.39	

No	Date	L.S.T.	Star I	m_1	Alt.	Az.	Star II	m_2	Alt.	Az.	Ext. II	Ext. I	Δm	Atmospherical conditions
		<i>h m</i>		<i>m</i>				<i>m</i>			<i>m</i>	<i>m</i>	<i>m</i>	
225		0 43.5	ϵ UMa	3.36	3° 26'	325° 57'	ζ Aur	3.90	38° 14'	300° 40'	0.10	0.64	-0.83	
226		0 44.5	β Gem	1.34	2 45	301 12	θ Aur	2.90	26 40	299 28	0.21	1.77	-0.10	
227		0 49.5	"	"	2 48	300 39	α Gem	1.52	7 43	302 42	0.83	1.01	-0.82	
228		0 52.5	θ UMa	3.43	3 17	331 39	ζ UMi	4.53	20 56	8 45	0.29	1.39	-0.17	
229		0 53.7	α Gem	1.52	8 51	302 55	β Aur	2.26	30 29	307 11	0.16	0.90	+0.28	
230		0 55.5	β Gru	2.43	7 02	157 24	δ Cap	3.18	24 32	128 23	0.24	0.99	+0.21	
231		0 58.5	γ Lep	3.90	4 10	241 02	λ Eri	4.54	19 07	247 18	0.34	0.98	-0.28	
232		1 03.2	α Gru	2.22	2 56	151 23	γ Cap	3.93	21 37	233 53	0.28	1.99	+0.25	
233		1 04.5	α Eri	0.89	2 13	184 07	α Phe	2.57	16 47	172 04	0.42	2.10	-0.23	
234		1 09.0	α UMa	2.07	5 36	345 07	δ Ori	2.66	21 21	256 38	0.29	0.88	-0.10	
235		1 10.2	β CMa	2.21	1 28	248 16	λ Eri	4.54	21 25	245 23	0.29	2.62	-0.71	
236		1 11.7	"	"	1 47	248 06	η Lep	3.90	9 06	247 43	0.75	2.44	-0.36	
237		1 14.0	"	"	2 15	247 46	τ Ori	3.84	22 14	248 37	0.27	1.90	-0.40	
238		1 16.0	"	"	2 40	247 33	μ Lep	3.48	17 10	238 54	0.39	1.66	-0.25	
239		1 16.7	β CMi	3.25	2 43	298 45	22 Ori	4.81	25 07	253 50	0.22	1.78	-0.08	
240		1 19.0	β CMa	2.21	3 16	247 06	γ Cet	3.79	57 00	219 15	0.03	1.61	+0.04	
241		1 23.5	"	"	4 10	246 31	α Lep	2.87	13 50	239 33	0.48	1.14	-0.13	
242		1 25.0	α CMa	-1.30	0 36	250 23	β Eri	3.12	26 48	245 54	0.20	4.62	-0.31	
243		1 25.7	"	"	0 48	240 16	β CMa	2.21	4 37	246 14	1.15	4.66	+0.23	
244		1 26.2	"	"	0 53	350 10	κ Ori	2.44	16 27	248 09	0.42	4.16	-0.14	
245		1 27.0	"	"	1 04	350 03	β Aur	2.26	36 18	305 59	0.11	3.67	-0.36	
246		1 27.7	"	"	1 12	249 57	ζ Ori	1.99	22 27	253 41	0.27	3.56	-0.21	
247		1 28.2	"	"	1 18	249 54	γ Ori	2.01	30 27	258 58	0.16	3.47	-0.16	
248		1 29.5	"	"	1 34	249 44	α PsA	1.57	19 35	144 47	0.33	3.20	+0.12	
249		1 30.0	α CMi	0.64	1 20	275 26	β CMi	3.25	5 17	276 37	1.05	3.66	+0.09	
250		1 31.2	"	"	1 40	275 13	μ Lep	3.48	19 56	236 28	0.32	3.16	+0.15	
251		1 32.2	"	"	1 53	275 08	α Lep	2.87	15 26	238 11	0.45	2.68	+0.01	
252		1 32.7	α CMa	-1.30	2 13	249 22	α Tau	1.08	46 53	261 58	0.06	2.44	+0.11	
253		1 33.5	α CMi	0.64	2 10	274 57	κ Ori	2.44	17 48	247 10	0.37	2.17	-0.19	
254		1 36.0	"	"	2 43	274 40	δ Ori	2.66	27 03	252 30	0.20	2.22	+0.34	
255		1 36.5	α CMa	-1.30	3 00	248 51	β Ori	0.62	25 50	242 22	0.21	2.13	+0.43	
256		1 37.5	β UMa	2.67	2 59	339 19	ν UMa	4.02	11 10	333 55	0.64	1.99	+0.28	
257		1 38.5	α CMi	0.64	3 24	274 18	ζ Ori	1.99	24 50	252 03	0.22	1.57	+0.07	
258		1 39.2	"	"	3 26	274 17	γ Ori	2.01	32 50	257 16	0.14	1.51	+0.02	
259		1 43.0	α CMa	-1.30	4 18	248 03	α Aur	0.33	46 42	306 47	0.06	1.69	+0.46	
260		1 44.5	α CMi	0.64	4 32	273 37	β Gem	1.34	14 14	294 32	0.48	1.18	$\pm$ 0.00	
261		1 45.2	β Col	3.30	2 52	225 14	ϵ Col	3.96	6 04	222 39	0.93	1.59	-0.19	
262		1 47.2	α UMa	2.07	8 02	341 39	β UMi	2.30	14 55	4 20	0.45	0.68	$\pm$ 0.00	
263		1 50.5	ζ CMa	3.30	2 35	232 49	λ Eri	4.54	29 08	238 23	0.17	1.41	-0.58	
264		1 52.5	"	"	4 16	232 03	θ CMa	4.22	6 55	251 53	0.86	1.78	+0.54	
265		1 54.7	β UMa	2.67	4 26	337 38	γ Per	3.19	63 50	337 35	0.02	0.54	-0.66	
266		2 02.0	β CMa	2.21	11 40	241 14	β Ari	2.96	79 57	201 00	0.00	0.75	+0.31	
267		2 04.5	ζ CMa	3.30	5 00	230 54	ζ Lep	3.84	20 48	237 41	0.29	0.83	-0.25	
268		2 07.5	ϵ Col	3.96	9 15	219 20	1 Per	5.19	70 50	319 28	0.01	1.24	+0.66	
269		2 09.0	β Col	3.30	6 28	221 56	ν Per	4.02	67 49	310 30	0.01	0.73	-0.12	
270		2 10.2	α Col	2.96	9 30	221 17	ϵ Per	3.14	66 44	306 09	0.01	0.19	-0.38	
271	Sept	1 09.9	α UMa	2.07	5 42	345 20	β UMi	2.30	15 39	6 56	0.46	0.69	-0.31	Clear at high altitudes, but rather hazy at the horizon. Very unsteady.
272	15th	1 11.4	α Gem	1.52	11 45	300 14	γ Ori	2.01	26 50	261 27	0.22	0.71	+0.21	
273	1934	1 13.4	β CMa	2.21	2 11	247 50	ϵ Ori	4.24	19 40	248 06	0.35	2.38	-0.64	
274		1 14.6	"	"	2 25	247 41	η Lep	3.90	9 54	247 15	0.75	2.44	-0.29	
275		1 16.0	"	"	2 43	247 33	γ Lep	3.80	7 15	238 49	0.97	2.56	+0.11	
276		1 18.0	β CMi	3.25	2 59	277 57	ϵ Gem	4.81	12 20	278 20	0.59	2.15	-0.12	
277		1 19.4	β CMa	2.21	3 24	247 04	β Lep	3.07	12 06	237 10	0.59	1.45	-0.48	
278		1 22.4	β CMi	3.25	3 54	277 25	ξ Gem	3.57	15 09	276 28	0.48	0.80	-0.87	
279		1 24.2	α CMa	-1.30	0 28	250 24	ϵ Ori	4.24	21 47	246 22	0.27	5.81	+0.31	
280		1 25.2	"	"	0 43	250 18	β Eri	3.12	26 48	245 53	0.21	4.63	-0.44	
281		1 25.6	"	"	0 46	250 15	ζ Lep	3.84	13 24	243 50	0.54	5.68	+0.66	
282		1 26.4	"	"	0 57	250 08	η Ori	3.64	25 20	250 54	0.23	5.17	+0.42	
283		1 26.9	"	"	1 04	250 06	β CMa	2.21	4 50	246 08	1.31	4.82	+0.25	
284		1 27.4	β CMa	2.21	4 57	245 59	α Lep	2.87	14 33	238 54	0.50	1.16	-0.06	
285		1 28.0	α CMa	-1.30	1 15	249 56	κ Ori	2.44	16 47	247 56	0.43	4.17	-0.11	
286		1 29.1	"	"	1 29	249 46	γ Gem	2.25	19 43	278 09	0.34	3.89	-0.08	
287		1 29.6	α CMi	0.64	1 21	275 30	ϵ Gem	4.81	14 50	276 58	0.50	4.67	+0.52	

No	Date	L.S.T.	Star I	m_1	Alt.	Az.	Star II	m_2	Alt.	Az.	Ext. II	Ext. I	Δm	Atmospherical conditions
		$h \quad m$		m				m			m	m	m	
288		1 30.2	α CMa	-1.30	1°42'	249°40'	γ Ori	2.01	30°53'	258°37'	0.16	3.47	-0.13	
289		1 30.9	α CMi	0.64	1 37	275 19	ξ Gem	3.57	17 00	275 27	0.40	3.33	-0.37	
290		1 31.6	α CMa	-1.30	1 58	249 30	α Gem	1.52	15 32	298 19	0.45	3.27	$\pm$ 0.00	
291		1 31.9	α CMi	0.64	1 50	275 10	β CMi	3.25	5 58	276 18	1.15	3.76	+0.33	
292		1 32.4	α CMa	-1.30	2 10	249 24	β Gem	1.34	12 05	295 40	0.62	3.26	+0.23	
293		1 32.9	α CMi	0.64	2 04	275 06	ϵ Gem	3.22	23 05	286 50	0.26	2.84	-0.30	
294		1 37.6	"	"	3 06	274 31	γ Gem	2.25	21 40	277 07	0.30	1.91	-0.26	
295		1 38.4	β UMa	2.67	3 04	339 15	ν UMa	4.02	11 14	333 51	0.66	2.01	-0.18	
296		1 39.2	α CMa	-1.30	3 33	248 27	α Tau	1.08	48 09	260 58	0.06	2.44	+0.59	
297		1 39.9	α UMa	2.07	7 29	342 19	γ Cas	2.48	58 35	11 12	0.03	0.44	-0.26	
298		1 43.2	α CMa	-1.30	4 20	247 59	β Ori	0.62	27 08	241 10	0.21	2.13	+0.66	
299		1 43.7	α CMi	0.64	4 23	273 45	α Gem	1.52	17 52	297 13	0.40	1.28	-0.15	
300		1 47.7	α UMa	3.87	10 50	318 59	ζ Aur	3.90	50 16	299 27	0.05	0.08	-0.42	
301		1 49.2	α CMa	-1.30	5 32	247 14	α Aur	0.33	47 46	306 55	0.06	1.69	+0.65	
302		1 49.9	β UMa	2.67	3 58	337 58	δ UMi	4.66	28 15	3 13	0.20	2.19	+0.57	
303		1 51.2	α CMi	0.64	5 58	272 49	β Gem	1.34	15 36	293 53	0.47	1.17	+0.22	
304		1 53.4	α Col	2.96	6 50	223 43	δ Eri	3.71	42 08	217 58	0.09	0.84	+0.06	
305		1 54.9	β Col	3.30	4 24	223 55	17 Eri	4.95	48 28	216 04	0.06	1.71	+0.28	
306		1 59.9	β CMa	2.21	11 13	241 30	β Ari	2.96	80 24	167 40	0.00	0.75	+0.25	
307		2 01.9	β UMa	2.67	4 12	336 02	α UMa	3.54	23 13	328 18	0.26	1.13	-0.38	
308		2 03.2	α Col	2.96	8 25	222 24	η Tau	3.13	66 52	260 57	0.01	0.18	-0.43	
309		2 04.9	ζ CMa	3.30	5 03	230 55	α Cet	5.08	58 24	215 28	0.03	1.81	+0.63	
310		2 17.2	40 Lyn	3.34	5 43	307 56	31 Lyn	4.33	19 52	309 26	0.36	1.35	+0.37	
311		2 18.4	β UMa	2.67	6 26	334 53	ϵ Cas	3.63	56 14	5 45	0.03	0.99	+0.11	
312		2 21.9	ϵ CMa	1.91	2 04	234 40	τ Ori	3.84	34 42	233 41	0.14	2.07	-1.06	
313		2 24.2	δ CMa	2.11	2 30	237 44	λ Eri	4.54	35 07	231 31	0.13	2.56	-0.11	
314		2 26.4	ϵ CMa	1.91	2 52	234 01	ζ CMa	3.30	8 37	227 50	0.85	2.24	-0.09	
315		2 37.7	δ CMa	2.11	4 45	235 56	γ Cet	3.79	63 05	181 20	0.02	1.70	+0.42	
316	Sept	2 24.3	ϵ CMa	1.91	2 27	234 20	γ Lep	3.80	19 18	228 01	0.36	2.25	+0.15	Hazy at the horizon except to the N. Rather steady. At start zodiacal light.
317	17th	2 25.6	δ CMa	2.11	2 33	237 30	λ Lep	4.45	30 25	230 00	0.15	2.49	+0.48	
318	1934	2 30.3	β Col	3.30	9 26	218 49	ϵ Eri	3.81	47 54	202 12	0.06	0.57	-0.01	
319		2 33.4	β UMa	2.67	7 50	333 24	δ Cas	2.99	57 37	16 40	0.03	0.35	-0.34	
320		2 36.8	δ Cnc	4.10	8 13	286 34	σ Gem	4.32	25 33	250 15	0.21	0.43	-0.24	
321		2 39.8	δ CMa	2.11	5 08	233 40	ι Ori	3.09	35 12	236 30	0.12	1.10	+0.03	
322		2 43.1	μ UMa	3.25	4 08	316 52	10 UMa	4.22	17 16	309 03	0.39	1.36	+0.09	
323		2 47.8	δ CMa	2.11	6 30	234 33	γ Eri	3.25	43 30	202 49	0.07	1.21	+0.36	
324		2 53.6	γ UMa	2.72	2 51	235 06	f UMa	4.71	21 35	318 32	0.28	2.27	+0.48	
325		2 55.0	λ UMa	3.70	7 30	316 10	α UMa	3.87	20 50	313 35	0.29	0.46	-0.27	
326		2 57.3	η CMa	2.65	3 40	233 04	c^1 Ori	4.80	39 09	233 30	0.10	2.25	+0.85	
327		3 02.3	γ UMa	2.72	3 35	334 08	h UMa	3.87	23 54	330 50	0.24	1.39	-0.04	
328		3 06.1	ϵ CMa	1.91	9 35	233 30	δ Ori	2.66	44 31	234 50	0.07	0.82	+0.25	
329		3 07.1	ζ Hya	3.34	6 24	273 30	α Gem	3.74	29 50	282 51	0.16	0.56	-0.31	
330		3 10.1	ϵ Leo	3.22	5 23	303 48	θ Gem	3.83	44 07	290 00	0.08	0.69	-0.33	
331		3 11.6	γ UMa	2.72	4 33	333 05	α UMa	3.54	30 29	326 14	0.16	0.98	-0.19	
332		3 13.3	η CMa	2.65	6 25	230 54	γ Lep	3.80	26 35	218 30	0.20	1.35	+0.49	
333		3 18.1	ϵ CMa	1.91	11 14	226 41	ζ Ori	2.14	44 00	232 31	0.07	0.30	-0.15	
334		3 19.1	γ UMa	2.72	5 14	332 15	ϵ Cas	3.63	53 40	16 45	0.04	0.95	-0.09	
335		3 26.1	ρ Pup	2.97	4 06	239 05	ξ Pup	3.57	7 06	236 10	0.86	1.46	+0.19	
336		3 28.8	"	"	5 07	239 51	σ^2 CMa	3.31	16 06	229 27	0.42	0.76	-0.31	
337		3 31.6	ϵ CMa	1.91	13 36	225 33	ϵ Ori	2.03	47 28	228 23	0.06	0.18	-0.17	
338		3 33.8	η CMa	2.65	10 09	227 40	μ Lep	3.48	38 23	209 53	0.10	0.93	+0.40	
339		3 37.3	π Pup	2.85	5 56	220 43	δ Lep	3.92	30 10	215 47	0.16	1.23	+0.30	
340		3 42.1	ρ Pup	2.97	7 03	236 57	β Col	3.30	18 14	205 49	0.36	0.69	-0.09	
341		3 43.3	ϵ UMa	2.03	3 41	338 47	γ UMa	2.72	7 48	329 46	0.81	1.50	+0.10	
342		3 44.8	γ Leo	2.39	3 13	291 07	ϵ Leo	3.22	12 15	290 49	0.58	1.41	-0.17	
343		3 45.3	ζ Leo	3.74	6 25	293 43	μ Leo	4.08	12 01	293 35	0.58	0.92	+0.05	
344		3 46.8	α Car	-0.67	0 44	202 24	γ Col	4.51	11 19	203 45	0.64	5.82	+1.28	
345		3 50.1	α Leo	1.61	2 56	282 29	γ Leo	2.39	4 31	290 43	1.15	1.93	+0.20	
346		3 52.8	α Car	-0.67	1 16	201 40	ζ CMa	3.30	20 46	213 13	0.29	4.26	+0.59	
347		3 55.1	α Hya	2.24	2 24	258 51	σ^2 CMa	3.31	20 19	224 52	0.32	1.39	-0.77	
348		3 57.1	"	"	3 14	258 20	ζ Hya	3.34	17 16	267 14	0.39	1.49	-0.09	
349		3 59.1	α Car	-0.67	1 44	200 50	β Lep	3.07	35 07	204 50	0.12	3.86	+0.99	
350		4 02.1	α Leo	1.61	5 31	281 02	γ Gem	2.25	52 51	257 20	0.04	0.68	-0.32	

APPENDIX II

CATALOGUE OF FOCUS TESTS OF THE 30-INCH REYNOLDS REFLECTOR.

The following catalogue contains 800 observations of focus of the Reynolds reflector, carried out by H. KNOX-SHAW, C. C. L. GREGORY and M. R. MADWAR during 1915—1934 and 75 similar tests by the author during 1934—1935. The focus tests are discussed in Chapter II of this paper.

The columns of the catalogue contain in order: 1) number in the catalogue, 2) date and 3) local sidereal time when the focus test was made, 4) star on which the focus test was made or, if no star was mentioned, the object which was to be photographed and in the neighbourhood of which the star used at the focussing was situated, 5) magnitude of the star, 6) right ascension, 7) declination, 8) hour angle, 9) altitude, 10) temperature, 11) reading of the capstan head (in whole revolutions and sixtieths of a revolution), 12) remarks on the atmospherical conditions and 13) remarks about the focus etc.

The abbreviations used in the two last columns are as follows: b = but, c = calm, cert = certain, cl = clear, f = fairly, g = good, h = hazy or haze, l = little or light, m = misty or mist, n = not, s = small, sl = slight, st = steady, str = strong, su = sudden, unst = unsteady, v = very, w = wind or windy, N = North or Northern etc. Other abbreviations are those generally used in astronomy or anyhow at once easy to understand. The altitudes are obtained by means of the MADWAR chart and are given within half a degree.

No	Date	L.S.T.	Object	<i>m</i>	α	δ	<i>h</i>	Alt.	<i>T</i>	<i>CH</i>	Weather	Remarks
1	Jan 4	^{<i>h</i>} 0 22	^{<i>m</i>} ϵ Cet	^{<i>m</i>} 3.75	^{<i>h</i>} 0 15	— 9°3	^{<i>h</i>} + 0.1	51°5	16°5	18; 55	f cl, unst, w	f even b unst
2	1915 5	1 57	δ UMi	4.4	18 00	+ 86.6	+ 8.0	29.5	18.0	18 45	cl, h, st, l w	v fair
3	10	4 32	BD 88°112	6.5	19 08	+ 88.9	+ 9.4	30.0	13.0	19 45	cl, f st, s w	fair
4	"	5 15	"	"	"	"	+ 10.1	30.0	13.0	19 50		
5	"	6 00	"	"	"	"	+ 10.9	30.0	12.5	19 58		
6	"	6 05	δ UMi	4.4	18 00	+ 86.6	+ 12.1	26.5	12.5	20 00		n v even
7	"	6 10	BAC 8213	5.5	23 28	+ 86.5	+ 6.7	29.5	12.5	19 53		n v ev. or cert
8	11	2 21	ϵ Cet	3.75	0 15	— 9.3	+ 2.1	41.0	16.5	18 55	cl, st, c	v g
9	"	3 30	SMF	F	8 00	+ 15.0	— 4.5	26.0	14.0	19 12		
10	"	5 22	"	"	"	"	— 2.6	51.5	13.0	19 15		
11	12	4 40	η Ori	3.4	5 20	— 2.5	— 0.7	55.0	12.0	19 45	cl, st, l w	
12	13	2 14	2 Cet	4.6	23 59	— 17.7	+ 2.2	33.0	16.5	18 40	cl, f st, c	
13	"	4 10	NGC 246	—	0 42	— 12.4	+ 3.5	24.0	12.0	19 15		
14	"	5 14	η Ori	3.4	5 20	— 2.5	— 0.1	57.5	12.0	19 20		
15	14	4 18	τ^6 Eri	4.3	3 30	— 21.9	+ 0.8	36.0	12.5	19 45	cl, st, c	n su
16	"	5 34	NGC 1518	—	4 02	— 21.4	+ 1.5	34.0	11.0	19 45		n v su
17	17	4 44	NGC 1537	—	4 10	— 31.8	+ 0.6	27.5	13.0	19 25	cl, st, l w	n v su
18	"	6 30	"	—	"	"	+ 2.3	20.0	12.0	19 30		
19	18	4 35	NGC 1700	—	4 52	— 5.0	— 0.3	55.0	15.0	19 35	cl, f st, str w	
20	19	5 09	NGC 1999	—	5 32	— 6.8	— 0.4	53.5	14.0	19 23	cl, f st, l w	
21	25	10 28	NGC 4027	—	11 54	— 18.7	— 1.4	37.5	14.0	19 50	v cl, st, l w	
22	Feb 4	3 40	PGC 588	—	2 31	+ 6.4	+ 1.1	51.0	14.0	19 10	cl, st, c	
23	"	5 55	NGC 1954	F	5 28	— 14.1	+ 0.4	46.0	11.5	19 25		
24	5	5 44	NGC 1964	F	5 29	— 22.0	+ 0.2	37.5	13.5	19 20	v cl, f st, s w	f g
25	"	7 35	"	—	"	"	+ 2.1	29.0	12.5	19 40		

No	Date	L.S.T.	Object	<i>m</i>	α	δ	<i>h</i>	Alt.	<i>T</i>	<i>CH</i>	Weather	Remarks
26	Feb 7	<i>h m</i> 6 07	PGC 588	<i>m</i> —	<i>h m</i> 2 31	+ 62.4	+ 3.6	34.0	13.5	19 30	cl, l w	v shimmery
27	1915	" 7 50	PGC 2053	5.5	7 42	— 34.0	+ 0.1	26.0	12.5	19 42		v shimmery
28	" 8	3 56	τ^6 Eri	4.3	3 30	— 21.9	+ 0.4	37.5	16.0	18 55	cl, r unst, w	
29	" "	6 00	"	"	"	"	+ 2.5	26.5	15.0	19 10		
30	" "	6 11	NGC 1999	—	5 32	— 6.8	+ 0.6	52.0	14.0	19 30	cl, unst, str w	f g
31	" "	7 00	"	—	"	"	+ 1.5	47.0	13.5	19 40		n v even
32	" 9	6 45	ξ Pup	3.5	7 46	— 24.6	— 1.0	33.5	13.0	19 35	cl, st, s w	
33	" "	6 58	ρ Pup	2.9	8 04	— 24.1	— 1.1	32.5	11.5	19 40		
34	10	6 19	NGC 2217	F	6 18	— 27.2	+ 0.0	33.0	12.5	19 25	f cl, r unst, w	
35	16	4 43	ν^4 Eri	3.6	4 15	— 34.0	+ 0.5	26.0	19.0	18 45	cl, w	v low!
36	" "	6 58	ι Ori	2.9	5 31	— 6.0	+ 1.4	49.0	15.5	19 48	f cl, f st, v str w	
37	" "	7 25	NGC 2023	B	5 37	— 2.3	+ 1.8	48.0	14.5	19 50		
38	" "	8 40	"	B	"	"	+ 3.0	36.0	13.5	19 40		
39	17	7 02	NGC 2327	—	6 59	— 11.2	+ 0.0	49.0	16.0	19 25	s th, st, l s w	
40	20	12 26	r Cen	—	13 07	— 32.1	— 0.7	27.0	11.0	20 00	cl, v st, c	g
41	21	12 30	NGC 5253	—	13 34	— 31.1	— 1.1	27.0	13.5	20 05	cl, st, w	v fair
42	" "	13 45	"	—	"	"	+ 0.2	28.5	12.5	20 10		l unst
43	22	12 19	NGC 5334	—	13 48	— 0.6	— 1.5	52.5	12.5	19 55	cl, st, c	
44	" "	12 20	[NGC 5334] +	—	13 30	"	— 1.2	54.5	12.5	20 20		
45	23	11 37	NGC 4597	—	12 35	— 5.3	— 1.0	52.0	15.0	20 15	cl, st, s w	
46	" "	11 52	"	—	"	"	— 0.7	53.0	15.0	20 10		
47	" "	14 18	"	—	"	"	+ 1.7	47.0	14.0	20 02		
48	24	12 41	γ Crv	2.8	12 11	— 17.1	+ 0.5	42.5	17.0	19 48	cl, st, c	
49	" "	12 42	η Vir	4.0	12 16	— 0.2	+ 0.4	59.0	17.0	19 50		
50	" "	14 45	γ Crv	2.8	12 11	— 17.1	+ 2.6	30.5	16.0	19 50		
51	" "	13 45	NGC 5236	—	13 31	— 29.3	+ 0.2	31.0	17.5	20 15	cl, st, s w	
52	" "	15 00	"	—	"	"	+ 1.5	27.5	16.5	20 10		
53	March 4	6 01	AG Strass 1356	—	4 56	— 5.9	+ 1.1	51.0	19.5	18 35	v cl, f st, w	
54	" "	6 35	ι Ori	2.9	5 31	— 6.0	+ 1.1	51.0	18.0	18 35		l patchy
55	" 5	6 20	NGC 1999	—	5 32	— 6.8	+ 0.8	51.0	17.5	18 45	cl, st, l w	
56	" "	7 20	"	—	"	"	+ 1.8	45.0	16.0	18 40		
57	6	6 09	ζ Ori	2.05	5 36	— 2.0	+ 0.5	57.0	18.0	18 35	v cl, st, c	
58	10	7 54	NGC 2517	F	7 58	— 12.0	— 0.1	48.0	26.0	18 40	cl, r unst, l s w	patchy
59	" "	9 15	SMF	F	7 00	+ 15.0	+ 2.2	56.0	24.5	18 45		
60	" "	9 55	"	—	"	"	+ 2.9	47.5	24.0	18 55		
61	" 14	8 25	[NGC 2792] +	—	9 09	— 32.0	— 0.7	27.5	16.5	18 55	f cl, f st, w	
62	" 18	8 56	NGC 2727	—	8 56	— 3.0	$\pm$ 0.0	57.0	16.0	19 00	cl, r unst, l w	g
63	" 19	9 46	κ Hyd	5.0	9 36	— 14.0	+ 0.2	46.0	17.0	18 55	cl, unst, str w	only fair Silvering
64	Apr 17	10 24	α Hyd	2.2	9 23	— 8.3	+ 1.0	48.5	20.5	18 12	v th, unst, str w	
65	May 2	11 08	NGC 3673	vF	11 20	— 26.2	— 0.2	34.0	22.0	18 20	cl, unst, v str w	uneven
66	" 4	11 46	γ Crv	2.8	12 11	— 17.1	— 0.4	43.0	21.5	18 25	v cl, f st, str w	unst
67	" 5	12 20	ξ Hyd	3.7	11 29	— 31.4	+ 0.8	27.5	20.5	18 35	cl, f st, str w	
68	" 7	12 13	PGC 3095	5.1	11 42	— 39.9	+ 0.5	19.0	21.5	18 28	cl, r unst, v str w	
69	" "	12 40	AG Wien 4511	6.2	12 10	— 9.7	+ 0.5	49.0	21.0	18 15		
70	" "	13 00	PGC 3448	4.8	13 13	— 17.7	— 0.2	42.0	20.5	18 12		
71	" 13	18 19	π Sgr	3.0	19 05	— 21.2	— 0.8	37.5	21.0	18 40	v cl, f st, l w	unst
72	" 14	17 23	"	"	"	"	— 1.7	33.5	26.0	19 05	cl, unst, v strE w	
73	" 15	18 27	"	"	"	"	— 0.6	38.0	20.0	19 35	s clouds, st, w	
74	" 16	17 55	η Sgr	3.2	18 12	— 36.8	— 0.3	24.0	19.0	19 00		
75	" 17	17 35	ϕ Sgr	4.9	19 10	— 25.4	— 1.6	30.0	19.0	19 05	cl, f st, l w	
76	" 20	17 32	c Sgr	4.6	19 57	— 28.0	— 2.4	23.0	19.0	19 15	cl, f st, str w	uneven
77	" "	18 05	NGC 6729	—	18 55	— 37.1	— 0.8	22.0	20.0	19 05		
78	" 22	18 05	"	—	"	"	— 0.8	22.0	21.0	19 00		
79	" 24	18 03	"	—	"	"	— 0.9	22.0	19.5	19 15	cl, f st, l w	Silvering
80	June 5	13 37	α Leo	1.3	10 04	+ 12.4	+ 3.5	38.0	29.0	18 30	cl, unst, v str w	
81	" 6	13 41	NGC 5253	—	13 34	— 31.8	+ 0.1	28.0	29.5	18 28	cl, r unst, str w	
82	" 8	16 18	α Sco	1.2	16 24	— 26.2	— 0.1	34.0	27.5	18 30	cl, unst, str w	
83	" 9	13 38	α Leo	1.3	10 04	+ 12.4	+ 3.6	38.0	30.0	18 30	cl, f st, w	
84	" "	15 09	PGC 3112	6.5	11 47	+ 38.4	+ 3.4	47.0	27.0	18 40		
85	" 11	18 28	NGC 6729	—	18 55	— 37.1	— 0.4	23.0	25.0	19 20	cl, st, c	
86	" "	19 33	"	—	"	"	+ 0.6	22.5	23.5	19 05		
87	" 12	13 50	α Leo	1.3	10 04	+ 12.4	+ 3.7	36.0	30.5	18 25	f cl, unst, v str w	unst

No	Date	L.S.T.	Object	<i>m</i>	α	δ	<i>h</i>	Alt.	<i>T</i>	<i>CH</i>	Weather	Remarks
		<i>h m</i>		<i>m</i>	<i>h m</i>		<i>h</i>					
88	June 18	18 41	NGC 6729	—	18 55	— 37°1	— 0.2	23°0	25°5	19; 40	s th, f st, l w	
89	1915 19	18 45	"	—	"	"	— 0.2	23.0	25.0	19 25	cl, r unst, w	
90	22	19 12	"	—	"	"	+ 0.3	23.0	24.5	19 22	cl, f st, s w	
91	July 1	15 35	α Oph	2.1	17 31	+ 12.6	— 1.9	57.5	28.0	18 50	f cl, r unst, str w	
92	3	15 58	NGC 5705	—	14 35	— 0.3	+ 1.4	53.5	30.5	18 15	cl, unst, v str w	
93	5	15 21	NGC 6235	—	16 47	— 22.1	— 1.4	34.0	28.0	18 48	cl, r unst, w	
94	6	16 10	SMF	—	20 00	+ 15.0	— 3.8	35.0	28.0	18 40	cl, unst, str w	uneven
95	8	16 48	γ Aql	2.8	19 42	+ 10.4	— 2.9	45.0	29.0	18 35	cl, r unst, w	
96	"	17 15	NGC 6729	—	18 55	— 37.1	— 1.7	19.0	28.0	18 35		uneven
97	9	18 07	"	—	"	"	— 0.8	22.0	27.5	19 10	cl, unst, str w	r unev. and unst
98	10	16 25	NGC 6293	—	17 04	— 26.4	— 0.6	33.0	29.5	18 35	cl, r unst, str w	g
99	12	16 33	NGC 6337	—	17 15	— 38.4	— 0.7	21.0	29.0	18 40	cl, f st, w	
100	14	18 11	NGC 6729	—	18 55	— 37.1	— 0.7	22.0	30.0	18 50	cl, unst, str w	
101	15	17 30	"	—	"	"	— 1.4	20.0	31.5	18 40	cl, unst, str w	v unst
102	Aug 2	18 11	"	—	"	"	— 0.7	22.0	29.5	19 00	cl, r unst, str w	unst
103	3	18 00	"	—	"	"	— 0.9	22.0	28.5	18 43	cl, r unst, str w	
104	"	18 45	SMF	—	0 00	+ 15.0	— 5.2	17.0	27.0	18 35		uneven
105	6	18 42	NGC 6729	—	18 55	— 37.1	— 0.2	23.0	29.0	18 55	cl, f st, s w	
106	7	18 01	"	—	"	"	— 0.9	22.0	28.0	18 50	cl, f st, w	
107	"	18 45	SMF	—	0 00	+ 15.0	— 5.2	17.0	27.5	18 35		
108	9	18 24	NGC 6729	—	18 55	— 37.1	— 0.5	22.5	27.5	18 50	cl, r unst, w	
109	13	19 09	"	—	"	"	+ 0.2	23.0	30.0	18 38	cl, r unst, str w	
110	14	18 58	"	—	"	"	+ 0.0	23.0	30.0	18 40	cl, f st, w	even b r unst
111	"	19 45	SMF	—	1 00	+ 15.0	— 5.2	17.0	29.0	18 30		
112	30	18 17	NGC 6729	—	18 55	— 37.1	— 0.6	22.5	29.0	18 30	cl, unst, str w	uneven
113	31	18 21	"	—	"	"	— 0.6	22.5	29.0	18 30	cl, r unst, str w	
114	Sept 2	18 13	"	—	"	"	— 0.7	22.0	31.5	18 15	cl, st, l w	
115	3	18 32	"	—	"	"	— 0.4	23.0	31.0	18 20	cl, f st, w	
116	4	18 21	"	—	"	"	— 0.6	22.5	31.0	18 15	cl, str w	
117	7	18 33	"	—	"	"	— 0.4	23.0	30.0	18 32	cl, v unst, v str w	unst
118	8	18 37	"	—	"	"	— 0.3	23.0	28.5	18 35	cl, r unst, v str w	uneven
119	9	19 56	NGC 7214	vF	22 03	— 28.3	— 2.1	24.5	24.5	18 40	cl, r unst, str w	uneven
120	10	20 00	NGC 6772	F	19 09	— 2.9	+ 0.8	55.0	25.0	18 40	cl, f st, w	
121	11	18 49	NGC 6729	—	18 55	— 37.1	— 0.1	23.0	27.0	18 27	cl, f st, l w	
122	12	20 23	NGC 7214	—	22 03	— 28.3	— 1.7	27.5	27.0	18 35	cl, r unst, str w	
123	27	19 23	NGC 6729	—	18 55	— 37.1	+ 0.5	22.5	25.0	18 20	cl, unst, str w	v unst
124	29	19 30	"	—	"	"	+ 0.6	23.0	28.0	18 18	cl, r unst, s w	
125	Oct 1	21 53	NGC 7204	vF	22 01	— 31.5	— 0.1	28.5	25.5	18 30	cl, r unst, str w	
126	3	22 01	NGC 7410	F	22 49	— 40.2	— 0.8	18.5	26.0	18 30	cl, unst, v str w	unst
127	4	21 50	NGC 7171	—	21 56	— 13.7	— 0.1	46.0	26.0	18 33	cl, unst, str w	
128	5	22 24	NGC 7314	F	22 30	— 26.6	— 0.1	34.5	25.5	18 35	cl, unst, s w	unst
129	6	22 28	NGC 7410	vF	22 49	— 40.2	— 0.3	19.0	27.0	18 35	cl, f st, s w	
130	9	22 10	NGC 6903	F	20 18	— 19.6	+ 1.9	34.0	28.5	18 30	cl, f st, s w	
131	10	22 59	AGHarvII 7623	—	21 24	— 12.9	+ 1.6	40.5	25.5	18 55	cl, unst, w	
132	"	23 20	CPD-23°8259	—	22 55	— 23.1	+ 0.4	37.0	24.5	18 50		
133	11	22 18	AGHarvII 8612	—	23 12	— 14.4	— 0.9	42.0	23.5	18 50	f cl, r unst, str w	
134	13	22 41	NGC 6962	—	20 45	— 0.1	+ 1.9	49.0	21.0	18 55	f cl, f st, w	
135	28	21 09	"	—	"	"	+ 0.4	59.0	30.5	18 15	cl, unst, v str w	
136	30	23 32	NGC 7713	—	23 31	— 38.5	+ 0.0	21.5	29.0	18 35	cl, unst, str w	unst
137	Nov 1	23 55	NGC 7723	—	23 34	— 13.5	+ 0.3	46.0	22.0	18 45	cl, unst, str w	
138	2	23 59	PGC 127	—	0 32	— 25.3	— 0.5	34.5	21.0	18 50	cl, unst, v str w	unst
139	5	21 26	NGC 6962	—	20 42	— 0.1	+ 0.7	56.5	24.0	18 25	cl, f st, l w	g
140	9	0 26	NGC 10	—	0 03	— 34.4	+ 0.4	25.0	21.0	18 50	f cl, f st, w	
141	10	0 45	NGC 24	—	0 05	— 25.5	+ 0.7	34.0	22.0	18 40	f cl, st, l w	uneven Silvering
142	27	1 07	IC 48	—	0 38	— 8.7	+ 0.5	51.0	17.5	18 43	cl, f st, l s w	
143	28	1 41	NGC 945	—	2 24	— 11.0	— 0.7	48.0	16.5	18 50	cl, f st, c	g
144	Dec 1	1 53	NGC 584	—	1 26	— 7.4	+ 0.4	52.5	13.0	18 40	cl, st, c	
145	2	1 42	IC 48	—	0 38	— 8.7	+ 1.1	48.0	14.5	18 45	cl, f st, l w	
146	3	1 46	NGC 578	—	1 26	— 23.2	+ 0.3	36.5	14.5	18 40	cl, unst, w	unst
147	4	2 35	NGC 584	—	1 26	— 7.4	+ 1.1	49.0	15.0	18 45	cl, r unst, w	g
148	6	23 28	NGC 246	—	0 42	— 12.4	— 1.2	44.5	19.0	18 20	cl, f st, w	uneven
149	7	2 02	NGC 625	—	1 31	— 41.9	+ 0.5	17.5	17.0	18 45	cl, unst, str w	
150	9	2 25	NGC 1310	F	3 17	— 37.5	— 0.9	21.0	17.0	18 45	cl, r unst, str w	unst

No	Date	L.S.T.	Object	m	α	δ	h	Alt.	T	CH	Weather	Remarks
151	Dec 10	2 44	NGC 1326	F	h m	— 36°8	— 0.6	22°5	17°0	18; 45	cl, unst, str w	
152	1915 28	3 25	"	vF	3 20	"	+ 0.1	23.5	14.5	18 55	cl, st, l w	
153	30	3 33	NGC 584	—	1 26	— 7.4	+ 2.1	42.0	16.5	18 35	f cl, unst, w	
154	Jan 9	5 11	NGC 1535	—	4 10	— 13.0	+ 1.0	44.5	12.5	18 45	v cl, st, l w	
155	1916 26	3 03	NGC 1310	vF	3 17	— 37.5	— 0.2	22.5	13.5	18 25	cl, fst, c	
156	28	5 26	NGC 2090	B	5 43	— 34.3	— 0.3	26.0	11.0	18 35	v cl, v st, c	g
157	29	3 15	NGC 1326	vF	3 20	— 36.8	— 0.1	23.0	15.0	18 20	v cl, st, c	
158	30	5 34	NGC 945	B	2 24	— 11.0	+ 3.2	28.0	16.0	18 13	cl, st, w	
159	31	3 23	NGC 1360	—	3 29	— 26.1	— 0.1	34.0	17.0	18 18	cl, st, str w	
160	Feb 2	6 01	NGC 1600	—	4 27	— 5.3	+ 1.6	47.5	13.0	18 43	v cl, fst, v str w	
161	3	4 05	SMF	—	7 00	+ 15.0	— 2.9	47.5	14.5	18 20	cl, unst, v str w	unst
162	7	6 36	NGC 2185	B	6 06	— 6.2	+ 0.5	53.0	15.5	18 40	cl, r unst, v str w	
163	23	6 54	NGC 2695	—	8 49	— 2.7	— 1.9	47.0	16.0	18 45	cl, r unst, str w	
164	25	6 47	ζ Ori	2.05	5 37	— 2.0	+ 1.2	53.5	16.5	18 25	cl, fst, w	g
165	26	7 36	α CMa	1.6	6 41	— 16.6	+ 0.9	41.5	17.0	18 25	th, fst, l w	
166	March 5	7 48	SMF	—	9 00	— 35.0	— 1.2	22.5	21.0	18 50	f cl, r unst, str w	
167	6	7 52	NGC 2781	F	9 07	— 14.4	— 1.2	42.0	21.5	18 25	cl, unst, w	
168	7	8 11	NGC 2327	—	6 59	— 11.2	+ 1.2	45.5	22.0	18 30	cl, unst, v str w	g
169	22	7 10	NGC 2346	B	7 04	— 0.6	+ 0.1	59.0	22.0	18 08	cl, r unst, c	
170	23	8 59	NGC 3113	F	10 00	— 28.0	— 1.0	30.5	23.0	18 15	cl, fst, w	
171	27	7 45	NGC 2438	B	7 37	— 14.5	+ 0.1	45.5	25.0	18 00	f cl, fst, l w	
172	30	9 27	SMF	—	7 00	+ 15.0	+ 2.4	33.0	26.5	18 45	cl, unst, str w	
173	31	9 46	NGC 3354	—	10 38	— 35.8	— 0.9	22.5	20.0	18 38	cl, r unst, w	
174	Apr 1	9 50	NGC 3450	F	10 43	— 20.3	— 0.9	38.0	20.0	18 30	cl, r unst, w	
175	2	9 54	NGC 3354	vF	10 38	— 35.8	— 0.7	23.5	18.5	18 45	cl, r unst, w	
176	4	11 02	PGC 3047	—	11 30	— 32.3	— 0.5	27.5	16.5	18 55	cl, fst, str w	Silvering
177	21	11 09	NGC 3585	—	11 08	— 26.2	+ 0.0	34.0	22.5	18 35	cl, fst, v str w	
178	24	11 21	NGC 4594	—	12 35	— 11.1	— 1.2	45.5	26.0	18 40	cl, r unst, v str w	
179	30	11 29	"	—	"	"	— 1.1	46.0	21.5	18 40	cl, unst, v str w	r unst
180	May 5	12 34	NGC 4782	vF	12 49	— 12.0	— 0.3	48.0	24.5	18 30	cl, fst, str w	r uneven
181	7	17 42	NGC 6729	—	18 55	— 37.1	— 1.2	20.5	21.0	19 18	f cl, st, c	
182	8	17 46	"	—	"	"	— 1.2	20.5	21.5	19 20	f cl, fst, l w	
183	9	17 50	"	—	"	"	— 1.1	21.0	20.0	19 25	cl, fst, c	
184	11	17 08	NGC 6355	—	17 18	— 26.2	— 0.2	34.0	21.5	19 12	cl, fst, str w	
185	"	18 00	NGC 6553	—	18 04	— 25.9	— 0.1	34.0	21.0	19 05		
186	20	12 33	NGC 4781	—	12 49	— 10.0	— 0.3	49.5	24.5	18 20	f cl, unst, str w	
187	22	13 11	NGC 4593	—	12 34	— 4.8	+ 0.6	54.0	22.5	18 40	cl, r unst, v str w	
188	23	13 00	NGC 4902	—	12 56	— 14.0	+ 0.1	46.0	20.5	18 35	cl, r unst, v str w	
189	25	13 23	NGC 5128	—	13 20	— 42.5	+ 0.1	18.0	22.5	18 30	cl, r unst, str w	
190	26	13 27	NGC 5634	—	14 24	— 5.5	— 1.0	51.5	24.5	18 20	cl, fst, w	
191	29	18 19	NGC 6729	—	18 55	— 37.1	— 0.6	22.5	23.0	19 40	cl, fst, str w	
192	"	13 39	BD-7°3632	—	13 23	— 7.8	+ 0.3	52.0	31.0	18 15	f cl, fst, w	
193	"	14 30	BD-7°3586	F	13 11	— 7.1	+ 1.3	49.0	31.0	18 20		
194	June 1	18 01	NGC 6729	—	18 55	— 37.1	— 0.9	22.0	21.0	19 25	cl, fst, str w	
195	"	14 50	NGC 4941	F	12 59	— 5.0	+ 1.9	45.5	26.0	18 15	cl, r unst, str w	
196	7	18 29	NGC 6729	—	18 55	— 37.1	— 0.4	23.0	22.5	19 35	cl bl th, fst, str w	
197	"	19 25	"	—	"	"	+ 0.5	22.5	22.0	18 55		
198	9	19 31	"	—	"	"	+ 0.6	22.5	24.5	19 15	cl bl th, st, l w	
199	10	19 35	"	—	"	"	+ 0.7	22.0	23.5	19 00	str w	
200	11	19 35	"	—	"	"	+ 0.7	22.0	24.5	19 15	cl, fst, w	
201	12	19 39	"	—	"	"	+ 0.7	22.0	25.0	19 05	cl, fst, c	
202	"	19 55	"	—	"	"	+ 1.0	21.5	23.5	18 55		
203	25	16 25	NGC 6366	—	17 22	— 5.0	— 1.0	52.0	32.0	18 20		
204	July 1	17 48	NGC 6729	—	18 55	— 37.1	— 1.1	21.0	28.0	18 30	f st, l w	
205	2	16 52	NGC 6522	—	17 57	— 30.0	— 1.1	28.0	30.0	18 25	cl, fst, l w	
206	3	16 56	v Oph	3.5	17 54	— 9.8	— 1.0	47.5	31.0	18 20	cl, fst, w	
207	4	17 30	NGC 6729	—	18 55	— 37.1	— 1.4	20.0	28.0	18 35	cl, fst, w	
208	7	17 42	"	—	"	"	— 1.2	20.5	31.0	18 30	cl, fst, w	
209	"	18 50	"	—	"	"	— 0.1	23.0	29.0	18 25		
210	22	18 11	"	—	"	"	— 0.7	22.0	29.0	18 35	cl, fst, c	
211	23	17 30	v Oph	3.5	17 54	— 9.8	— 0.4	50.5	30.0	18 25	cl, fst, str w	
212	"	19 20	PGC 5166	5.5	20 05	— 36.3	— 0.7	23.5	28.0	18 25		
213	24	19 19	NGC 6535	—	17 59	— 0.3	+ 1.3	53.0	26.0	18 40	cl, fst, l w	

No	Date	L.S.T.	Object	<i>m</i>	α	δ	<i>h</i>	Alt.	<i>T</i>	<i>CH</i>	Weather	Remarks
		<i>h m</i>		<i>m</i>	<i>h m</i>		<i>h</i>					
214	July 25	17 23	NGC 6544	—	18 01	— 25°0	— 0.6	34°5	31°0	18; 10	cl, l w	
215	1916 26	18 27	NGC 6729	—	18 55	— 37.1	— 0.5	22.5	30.0	18 25	cl, f st, w	v shaky
216	30	17 58	γ^2 Sgr	3.1	18 00	— 30.4	— 0.0	29.5	29.0	18 25	cl, f st, w	
217	31	19 02	PGC 5180	5.9	20 09	— 27.3	— 1.1	31.0	29.0	18 35	cl, f st, l w	
218	Aug 1	18 21	NGC 6729	—	18 55	— 37.1	— 0.6	22.5	31.0	18 30	cl, f st, str w	
219	2	19 25	4 Cap	6.0	20 13	— 22.1	— 0.8	37.0	29.0	18 45	cl, f st, w	
220	3	20 29	1 Cap	4.3	21 18	— 17.2	— 0.8	41.5	27.0	18 55	cl, f st, w	
221	"	0 45	"	"	"	"	+ 3.4	25.0	25.0	18 45		
222	5	20 00	NGC 6729	—	18 55	— 37.1	+ 1.1	21.0	27.0	18 15	cl, f st, l w	
223	8	22 33	α PsA	1.3	22 53	— 30.1	— 0.3	29.5	26.0	18 55	cl, st, l w	
224	23	18 32	NGC 6729	—	18 55	— 37.1	— 0.4	23.0	28.0	18 25	cl, r unst, str w	
225	26	18 44	"	—	"	"	— 0.2	23.0	27.5	18 42	cl, r unst, w	r unst
226	27	18 03	"	—	"	"	— 0.9	22.0	30.0	18 15	cl, f st, l w	
227	"	18 55	SMF	—	0 00	+ 15.0	— 5.1	19.0	28.5	18 05		unst
228	29	19 56	"	—	"	"	+ 4.1	32.0	29.5	18 30	cl, unst, v str w	
229	31	19 04	NGC 6729	—	18 55	— 37.1	+ 0.2	23.0	29.5	18 25	cl, r unst, w	
230	Sept 1	18 53	"	—	"	"	— 0.0	23.0	31.0	18 15	cl, f st, w	
231	15	18 48	"	—	"	"	— 0.1	23.0	31.5	18 15	cl, f st, l w	
232	16	18 52	"	—	"	"	— 0.1	23.0	33.0	18 10	cl, unst, str w	
233	18	19 00	"	—	"	"	+ 0.1	23.0	28.5	18 23	cl, f st, str w	
234	19	19 04	"	—	"	"	+ 0.1	23.0	27.5	18 30	cl, str w	
235	22	19 16	"	—	"	"	+ 0.3	23.0	30.0	18 00	cl, unst, str w	unst
236	24	19 09	"	—	"	"	+ 0.2	23.0	27.5	18 25	cl, r unst, str w	
237	26	19 17	"	—	"	"	+ 0.4	23.0	26.5	18 18	cl, unst, str w	
238	27	19 21	"	—	"	"	+ 0.4	23.0	25.5	18 30	cl, f st, w	
239	28	19 25	"	—	"	"	+ 0.5	22.5	25.0	18 25	cl, f st, w	
240	Oct 25	21 11	NGC 24	—	0 05	— 25.5	— 2.9	21.5	21.5	18 40	cl, unst, v str w	
241	29	23 12	IC 5332	—	23 29	— 36.5	— 0.3	23.5	22.5	18 38	cl, r unst, str w	Silvering
242	Dec 1	8 09	ζ Arg	2.3	8 01	— 39.8	+ 0.1	20.0	16.5	19 47	cl, v st, s w	
243	1919 2	8 13	NGC 2811	—	9 11	— 15.9	— 1.0	41.5	16.5	19 40	a l cloud, st, c	
244	11	0 18	NGC 1514	—	4 03	+ 30.5	— 3.7	42.5	14.5	19 10	low m, unst	KET troubles.
245	14	2 44	β For	4.5	2 46	— 32.7	— 0.0	27.5	13.5	19 25	cl, f st	and unst
246	19	3 19	ϵ Eri	3.8	3 29	— 9.7	— 0.2	49.5	14.0	19 25	cl, f st	
247	30	10 00	γ Crv	2.8	12 12	— 17.1	— 2.2	33.0	11.5	19 00	cl, st, c	
248	31	10 04	ξ Hyd	3.7	11 29	— 31.4	— 1.4	26.0	11.0	19 00	low m, otherw. cl	
249	Jan 8	1 53	S. p. NGC 1407	—	3 36	— 18.9	— 1.7	36.0	16.5	19 15	cl, f st, str w	
250	1920 11	4 21	ν^4 Eri	3.6	4 15	— 34.0	+ 0.1	26.0	15.0	19 20	cl, st, l w	
251	14	5 33	—	—	5 33	— 10.0	$\pm$ 0.0	50.0	15.0	19 35	clouds, l w	
252	15	1 50	—	—	4 00	+ 2.0	— 2.2	45.0	19.5	19 10	cl, f st, l s w	
253	19	2 21	—	—	2 49	— 30.8	— 0.5	28.0	12.0	19 00	cl, f st	
254	21	2 59	γ CMa	4.1	7 00	— 15.5	— 4.0	16.0	13.5	19 00	cl, st	
255	22	2 33	NGC 1976	—	5 30	— 5.5	— 3.0	34.0	16.5	19 00	s low clouds, st	
256	23	2 52	NGC 1535	—	4 10	— 13.0	— 1.3	43.0	16.0	19 15	cl, st	
257	24	5 27	"	—	"	"	+ 1.3	43.0	12.0	19 15	cl, st	
258	29	11 43	NGC 4818	—	12 52	— 8.0	— 1.2	48.0	9.5	20 07	cl, f st	
259	Febr 11	8 53	α Hyd	2.2	9 24	— 8.3	— 0.5	51.0	6.0	19 50	low clouds, r unst	
260	15	9 49	NGC 2359	—	7 14	— 13.0	+ 2.6	31.5	10.5	19 54	cl, f st	
261	16	5 11	ζ Ori	2.05	5 37	— 2.0	— 0.4	58.0	14.0	19 15	cl, f st	
262	17	6 31	NGC 1976	—	5 30	— 5.5	+ 1.0	51.5	13.0	19 30	low clouds, st	
263	18	5 05	"	—	"	"	— 0.4	54.5	13.5	19 35	cl, f st, str w	
264	20	5 13	NGC 1535	—	4 10	— 13.0	+ 1.0	44.5	13.5	19 20	cl, f st, str w	
265	21	7 17	NGC 3054	—	9 50	— 25.2	— 2.5	24.0	12.0	19 25	cl, st	
266	28	13 26	NGC 5182	—	13 52	— 27.6	— 0.4	32.0	9.5	20 00	cl, h, st	
267	March 8	6 20	NGC 1976	—	5 30	— 5.5	+ 0.8	52.5	19.5	19 10	s clouds, f st	
268	9	8 24	μ Hyd	4.1	10 22	— 16.4	— 2.0	35.0	17.0	19 25	cl, f st, w	
269	13	8 25	"	—	"	"	— 2.0	35.0	15.0	19 15	v unst	bad »summer»
270	14	6 58	NGC 2792	—	9 09	— 42.0	— 2.2	11.0	17.0	19 15	clouds, f st	night
271	16	8 36	NGC 2781	—	9 07	— 14.4	— 0.5	44.0	18.0	19 20	cl, f st, str w	
272	17	8 40	δ Leo	2.6	11 10	+ 21.0	— 2.5	55.5	18.0	19 10	cl, unst, v str w	
273	18	8 44	NGC 3456	—	10 49	— 15.5	— 2.1	36.0	22.0	18 55	clouds, f st	
274	21	8 56	NGC 2855	—	9 17	— 11.5	— 0.4	48.0	18.0	19 25	cl, f st	
275	23	10 04	NGC 2261	—	6 34	+ 8.8	+ 3.5	37.0	16.0	19 20	cl, st	
276	25	15 09	IC 4603	—	16 19	— 24.2	— 1.2	32.5	12.0	20 10	cl, st	

No	Date	L.S.T.	Object	<i>m</i>	α	δ	<i>h</i>	Alt.	<i>T</i>	<i>CH</i>	Weather	Remarks
		<i>h m</i>		<i>m</i>	<i>h m</i>		<i>h</i>					
277	March 27	15 17	NGC 5812	—	14 56	— 7°1	+ 0.3	52°0	12°0	20; 10	cl, st	
278	1920 28	15 21	NGC 5968	—	15 34	— 30.2	— 0.2	30.0	13.5	19 50	cl, st	
279	29	15 25	NGC 6139	—	16 21	— 38.6	— 0.9	20.0	12.0	19 45	cl, st	
280	30	15 29	π Sco	3.0	15 54	— 25.9	— 0.4	34.0	13.0	19 50	cl, st	
281	Apr 6	8 29	NGC 2855	—	9 17	— 11.5	— 0.8	47.0	30.5	18 25	f cl, unst, str w	
282	7	9 48	μ Hyd	4.1	10 22	— 16.4	— 0.6	42.0	23.5	19 25	cl, r unst, str w	large change!
283	9	9 56	NGC 3585	—	11 08	— 26.2	— 1.2	31.0	21.0	19 15	cl, r unst, r str w	
284	10	10 15	NGC 3936	—	11 47	— 26.4	— 1.5	30.0	18.0	19 15	cl, r unst	
285	11	11 34	NGC 4504	—	12 27	— 7.0	— 0.9	51.0	18.0	19 20	cl, f st	
286	13	10 42	T Pyx	—	9 01	— 32.0	+ 1.7	24.0	19.0	18 50	cl, f st	
287	14	11 16	IC 3253	—	9 01	— 32.0	+ 2.3	20.0	21.5	19 20	cl, st	
288	16	10 54	IC 2995	—	12 01	— 27.4	— 1.1	30.5	19.5	19 10	cl, unst	
289	20	10 55	NGC 4597	—	12 35	— 5.3	— 1.7	47.5	22.5	19 05	cl, f st	
290	21	11 29	T Pyx	—	9 01	— 32.0	+ 2.5	19.0	23.5	19 15	cl, r unst	
291	22	11 48	NGC 4699	—	12 44	— 8.1	— 0.9	49.5	26.0	19 15	cl, f st	
292	24	17 06	NGC 6522	—	17 57	— 30.0	— 0.8	28.5	23.5	19 55	cl, st	
293	26	16 59	NGC 6302	—	17 07	— 37.0	— 0.1	23.0	20.5	19 05	cl, r unst, v w	half gale
294	29	17 26	NGC 6729	—	18 55	— 37.1	— 1.5	19.5	17.0	19 20	cl, f st	Silvering
295	May 8	12 06	NGC 4958	—	13 01	— 7.5	— 0.9	50.0	27.0	19 00	cl, r unst, v str w	
296	11	12 33	NGC 4965	—	13 02	— 27.7	— 0.5	32.0	24.0	18 40	cl, r unst	
297	13	12 26	NGC 5102	—	13 16	— 36.1	— 0.8	22.5	23.0	18 40	cl, r unst	
298	14	12 45	NGC 5427	—	13 58	— 5.5	— 1.2	50.5	21.5	18 50	cl, r unst	
299	16	17 33	PGC 4370	—	17 09	— 26.5	+ 0.4	33.0	19.0	19 30	cl, unst, v str w	
300	17	18 22	ϵ Sgr	1.95	18 19	— 34.4	+ 0.0	25.5	17.5	19 30	v cl, l cloud, st	
301	18	18 26	"	"	"	"	+ 0.1	25.5	18.5	19 25	cl, f st	
302	19	18 00	NGC 6729	—	18 55	— 37.1	— 0.9	22.0	20.0	19 15	slow cloud, st	
303	20	18 04	"	—	"	"	— 0.8	22.0	21.0	19 15	cl, st	
304	20	13 37	NGC 5494	—	14 07	— 30.2	— 0.5	29.0	25.0	18 40	cl, st	
305	23	16 46	NGC 6342	—	17 15	— 19.5	— 0.5	39.5	22.0	19 30	cl, r unst	
306	25	18 24	NGC 6729	—	18 55	— 37.1	— 0.5	22.5	21.5	19 40	cl, r unst, prstr w	
307	26	18 28	"	—	"	"	— 0.5	22.5	23.0	19 40	cl, f st, r str w	
308	June 6	13 44	ψ Vir	4.9	12 50	— 9.1	+ 0.9	49.0	32.0	18 25	cl, f st, str w	uneven
309	8	14 22	ξ^a Lib	5.6	14 52	— 11.1	— 0.5	48.0	29.5	18 55	cl, f st, s w	
310	10	15 00	μ Ser	3.6	15 45	— 3.2	— 0.8	55.0	28.0	19 00	v cl, st, w	
311	13	17 54	ϵ Sgr	1.95	18 19	— 34.4	— 0.4	25.0	24.5	19 12	cl, st, l w	
312	15	18 02	NGC 6729	—	18 55	— 37.1	— 0.9	22.0	24.0	19 20	lc st, w	n v su
313	"	14 35	α Oph	2.1	17 31	+ 12.6	— 2.9	45.0	28.5	18 35	cl, r unst, str w	
314	17	18 25	NGC 6729	—	18 55	— 37.1	— 0.5	22.5	25.0	19 22	cl, r unst, v str w	
315	19	18 18	"	—	"	"	— 0.6	22.5	25.5	19 30	cl, st, w	
316	21	18 26	"	—	"	"	— 0.5	22.5	27.5	19 25	cl, st, s w	normal
317	22	18 45	"	—	"	"	— 0.2	23.0	27.0	19 07	r unst, l w	
318	23	18 34	"	—	"	"	— 0.4	23.0	29.0	19 10	cl, f st	
319	24	18 53	"	—	"	"	— 0.0	23.0	25.5	19 25	cl, f st	
320	25	18 57	"	—	"	"	+ 0.0	23.0	25.5	19 25	cl, st, w	
321	July 6	15 58	NGC 6302	—	17 07	— 37.0	— 1.1	21.0	30.0	18 25	cl, f st	
322	8	16 21	NGC 6325	—	17 12	— 23.6	— 0.9	35.0	30.5	18 25	cl, f st	
323	9	17 55	NGC 6539	—	17 59	— 7.6	— 0.1	52.5	29.0	18 40	cl, f st	
324	10	18 44	NGC 6729	—	18 55	— 37.1	— 0.2	23.0	29.0	18 45	cl, f st	
325	11	18 48	"	—	"	"	— 0.1	23.0	29.5	18 45	cl, f unst	
326	12	17 06	NGC 6440	—	17 43	— 20.3	— 0.6	39.0	31.5	18 20	cl, r unst, str w	
327	13	19 10	NGC 6729	—	18 55	— 37.1	+ 0.3	23.0	25.5	19 00	cl, f st	
328	14	17 14	NGC 6629	—	18 20	— 23.3	— 1.1	34.5	28.0	18 35	cl, unst, str w	
329	15	16 48	NGC 6357	—	17 18	— 34.1	— 0.5	26.0	28.5	18 40	cl, f st	
330	17	17 26	"	—	"	"	+ 0.1	26.0	30.0	18 40	cl, r unst	
331	18	17 30	NGC 6569	—	18 07	— 31.9	— 0.6	26.0	29.5	18 30	cl, r unst	
332	19	17 34	IC 1287	—	18 26	— 10.9	— 0.9	47.0	30.0	18 45	cl, r unst, str w	
333	20	18 23	NGC 6729	—	18 55	— 37.1	— 0.5	22.5	29.0	18 00	cl, f st	
334	23	21 31	NGC 7184	—	21 57	— 21.3	— 0.4	38.5	26.5	19 10	cl, f st	
335	24	21 35	"	—	"	"	— 0.4	38.5	25.5	19 10	cl, f st	
336	27	23 02	Com. Tempel II	—	2 08	— 1.4	— 3.1	36.0	25.5	19 25	cl, f st	
337	Aug 4	17 22	NGC 6729	—	18 55	— 37.1	— 1.5	19.5	31.0	18 20	cl, unst	
338	5	17 26	"	—	"	"	— 1.5	19.5	32.5	18 10	cl, r unst	
339	7	18 19	"	—	"	"	— 0.6	22.5	32.0	18 20	l clouds, unst, v w	

No	Date	L.S.T.	Object	<i>m</i>	α	δ	<i>h</i>	Alt.	<i>T</i>	<i>CH</i>	Weather	Remarks
		<i>h m</i>		<i>m</i>	<i>h m</i>		<i>h</i>					
340	Aug 9	18 42	NGC 6729	—	18 55	— 37°1	— 0.2	23°0	31°0	18; 45	f st, str w	
341	1920 11	18 20	"	—	"	"	— 0.6	22.5	33.0	18 40	cl, f st	
342	13	18 43	"	—	"	"	— 0.2	23.0	30.0	18 35	cl, v unst, v str w	
343	14	18 02	"	—	"	"	— 0.9	22.0	30.5	18 35	cl, r unst	
344	17	18 29	"	—	"	"	— 0.4	22.5	33.0	18 20	s clouds, r unst	
345	Jan 3	4 05	IC 2118	—	5 02	— 7.4	— 1.0	50.0	14.5	19 20	cl, f st	Silvering
346	1921 4	1 24	NGC 808	—	1 59	— 23.8	— 0.6	35.5	16.0	19 00	cl, f st, v str w	
347	5	1 58	NGC 1201	—	3 00	— 26.4	— 1.0	31.5	18.5	18 35	s SW clouds, f st	
348	7	2 06	NGC 450	—	1 10	— 1.4	+ 0.9	56.0	16.0	19 05	s low clouds, f st	
349	9	4 29	NGC 1320	—	3 20	— 3.4	+ 1.1	52.0	14.5	19 20	cl, f st	
350	10	2 03	NGC 1288	—	3 13	— 32.9	— 1.2	24.0	16.0	19 05	cl, f st	
351	11	4 22	NGC 1879	—	5 16	— 32.2	— 0.9	27.0	13.0	19 15	cl, f st	
352	13	4 15	NGC 1999	—	5 32	— 6.8	— 1.3	47.5	14.0	19 15	cl, r unst	
353	14	4 49	NGC 1954	—	5 28	— 14.1	— 0.6	45.0	14.0	19 10	cl, f st	
354	16	10 56	NGC 4050	—	11 58	— 15.8	— 1.0	42.0	12.0	19 45	cl, r unst, v str w	
355	17	11 00	NGC 4965	—	13 02	— 27.7	— 2.0	26.0	12.5	20 00	cl, r unst, v str w	
356	27	5 41	NGC 1779	—	5 00	— 9.3	+ 0.7	49.5	11.5	19 30	cl, f st	
357	31	7 13	Jupiter VIII	—	11 17	+ 6.1	— 4.1	28.0	10.5	19 20	cl, l unst	coord. of Jup.
358	Febr 1	7 02	"	—	"	"	— 4.2	26.0	11.5	19 30	cl, f st	
359	4	7 29	"	—	11 16	+ 6.3	— 3.8	31.0	14.0	19 10	cl, low cloud, st	
360	5	7 03	"	—	"	"	— 4.2	26.0	14.0	19 10	cl, st, pr. str NE w	
361	7	6 41	NGC 3388	—	10 37	+ 14.3	— 3.9	33.5	14.5	19 10	cl, unst, str NE w	
362	9	7 04	Jupiter VIII	—	11 14	+ 6.5	— 4.2	26.0	14.0	19 20	cl, f st	
363	11	9 12	"	—	11 13	+ 6.6	— 2.0	53.5	14.0	19 25	a low cloud, f st	
364	26	7 55	"	—	11 06	+ 7.3	— 3.2	39.0	12.5	19 10	a low cloud, f st	
365	27	8 14	"	—	"	+ 7.4	— 2.9	43.0	11.5	19 15	cl, f st	
366	28	8 18	NGC 1555	—	4 16	+ 19.3	+ 4.0	34.5	9.5	19 30	cl, st	
367	March 1	7 51	NGC 1976	—	5 30	— 5.5	+ 2.3	41.0	10.0	19 25	clouds, st	
368	2	7 40	β Leo	2.2	11 45	+ 15.0	— 4.1	31.5	11.0	19 10	v cl, v st, l w	n v su
369	4	8 18	Jupiter VIII	—	11 03	+ 7.6	— 2.8	45.0	10.5	19 10	cl, st	
370	5	7 52	NGC 2261	—	6 34	+ 8.8	+ 1.3	61.5	13.5	19 10	cl, f st	
371	8	8 49	Jupiter VIII	—	11 02	+ 7.8	— 2.2	51.5	15.0	19 10	cl, st	
372	13	8 53	"	—	10 59	+ 8.1	— 2.1	53.5	14.5	19 10	cl, f st	
373	16	14 17	"	—	10 58	+ 8.2	+ 3.3	38.5	11.0	19 50	cl, unst, NE gale	v bad
374	19	14 00	"	—	10 57	+ 8.3	+ 3.0	43.0	10.5	19 50	S cloud-bank, st	
375	19	15 34	NGC 4321	—	12 18	+ 16.4	+ 3.3	42.0	9.0	19 50	s E clouds, st	
376	28	9 52	Jupiter VIII	—	10 53	+ 8.7	— 1.0	64.5	18.5	19 00	l cloud, f st, str w	
377	30	8 15	"	—	10 52	+ 8.8	— 2.6	47.5	23.5	18 50	cl, f st	
378	31	9 34	NGC 4565	—	12 31	+ 26.5	— 3.0	51.0	14.5	18 55	cl, f st	
379	Apr 2	8 12	Jupiter VIII	—	10 51	+ 8.9	— 2.6	47.5	21.5	19 00	l cloud, l unst, vw	
380	3	10 16	NGC 2261	—	6 34	+ 8.8	+ 3.7	34.5	18.0	19 10	cl, st	
381	7	12 58	Jupiter VIII	—	10 49	+ 9.0	+ 2.2	52.5	18.5	18 45	f cl, r unst	
382	"	8 32	"	—	"	+ 9.1	— 2.3	51.5	19.5	19 00	cl, f st	
383	9	12 26	"	—	10 48	"	+ 1.6	58.5	18.0	19 00	cl, f st	
384	16	14 49	"	—	10 47	+ 9.3	+ 4.0	31.0	17.0	18 45	v cl, f st	
385	29	12 14	NGC 3623	—	11 14	+ 13.6	+ 1.0	68.5	18.5	19 15	cl, r unst	Silvering
386	30	12 18	NGC 3627	—	11 15	+ 13.5	+ 1.0	68.0	20.0	18 55	cl, l unst, str w	n even
387	May 1	11 51	NGC 4594	—	12 35	— 11.1	— 0.7	48.0	21.0	19 00	cl, r unst	
388	5	12 22	NGC 4753	—	12 47	— 0.6	— 0.4	59.0	21.0	19 10	h, r unst, str w	pr sharp
389	10	14 58	NGC 4216	—	12 11	+ 13.7	+ 2.8	48.0	18.0	19 00	cl, r unst	
390	11	12 46	Com. Pons-Win.	—	17 35	+ 46.0	— 4.8	32.0	20.0	18 45	low cloud, unst	
391	13	18 34	NGC 6729	—	18 55	— 37.1	— 0.3	23.0	16.5	19 30	low cloud, st	
392	15	18 27	"	—	"	"	— 0.5	22.5	20.0	19 30	m at hor., r unst	
393	June 5	18 20	η Sgr	3.2	18 12	— 36.8	+ 0.1	23.0	22.5	19 25	cl, st, s w	
394	10	18 24	"	"	"	"	+ 0.2	23.0	31.0	19 15	f cl, st, SE w	
395	12	18 47	"	"	"	"	+ 0.6	22.5	24.0	20 00	cl, st, c	large change!
396	15	18 59	"	"	"	"	+ 0.8	22.0	23.0	19 30	cl, N clouds, st, w	
397	Oct 21	20 59	γ Mic	4.7	20 57	— 32.6	+ 0.0	27.5	23.5	18 40	s clouds, f st, w	
398	22	22 47	α PsA	1.3	22 53	— 30.0	— 0.1	30.0	21.0	18 55	cl, f st, w	
399	26	23 33	ϵ^2 Aqr	3.8	23 05	— 21.6	+ 0.5	38.0	24.0	19 00	cl, r unst, l w	r unst
400	27	23 37	"	"	"	"	+ 0.5	38.0	22.5	19 00	cl, st, s w	
401	28	23 41	"	"	"	"	+ 0.6	38.0	22.5	18 55	cl, st, c	fair

No	Date	L.S.T.	Object	<i>m</i>	α	δ	<i>h</i>	Alt.	<i>T</i>	<i>CH</i>	Weather	Remarks
		<i>h m</i>		<i>m</i>	<i>h m</i>		<i>h</i>					
402	Nov 1	23 41	2 Cet	4.6	0 00	— 17°8	— 0.3	42°0	18°0	19; 20	cl, st, s w	fair
403	1921 4	23 53	1 Cet	3.75	0 15	— 9.3	— 0.4	51.0	19.5	18 55	cl, st, l w	g
404	7	5 33	ε Lep	3.3	5 02	— 22.5	+ 0.5	37.0	19.0	19 27	S clouds, st, w	g
405	9	5 11	»	»	»	»	+ 0.1	37.5	18.0	19 27	v cl, st, str w	Silvering
406	17	22 30	—	F	0 00	— 32.0	— 1.5	25.0	23.5	18 45	f cl, st, c	n v su
407	18	22 19	γ Gru	3.2	21 49	— 37.7	+ 0.5	22.0	22.0	18 50	cl, st, l w	g
408	22	1 20	1 Cet	3.75	0 15	— 9.3	+ 1.1	48.0	18.0	19 15	cl, st, l w	
409	25	1 17	12 Cet	6.05	0 26	— 4.4	+ 0.8	53.0	15.5	19 30	cl, st, c	
410	26	1 21	»	»	»	»	+ 0.9	52.5	15.5	19 10	v cl, st, l w	first class night
411	27	1 25	2 Cet	4.6	0 00	— 17.8	+ 1.4	38.5	16.0	19 15	cl, f st, w	
412	28	23 43	»	»	»	»	— 0.3	42.0	18.0	19 00	clouds, r unst, w	
413	Dec 2	2 14	67 Cet	5.7	2 13	— 6.8	+ 0.0	53.5	16.5	19 15	v cl, st, c	
414	3	2 03	»	»	»	»	— 0.2	53.5	16.0	19 15	cl, f st, w	
415	23	3 22	NGC 1232	—	3 05	— 21.0	+ 0.3	38.5	14.5	19 30	l cloud, st, c	
416	Jan 2	1 46	β Eri	2.9	5 04	— 5.2	— 3.3	31.0	16.0	19 00	cl, st, l w	
417	1922 26	5 36	NGC 2438	—	7 38	— 14.6	— 2.0	36.5	13.0	19 25	clouds, f st, l w	
418	28	10 13	Jupiter VIII	—	13 12	— 6.1	— 3.0	34.0	12.0	19 40	v cl, v st, c	
419	31	10 25	»	—	»	»	— 2.8	36.0	12.5	19 45	cl, v st, c	n v su
420	Feb 1	11 12	ψ Vir	4.9	12 50	— 9.1	— 1.6	45.0	13.0	19 45	cl, st, l w	uneven
421	14	4 21	θ Cet	3.8	1 20	— 8.6	+ 3.0	31.5	17.5	18 55	cl, l w	unst
422	21	8 34	ξ Gem	3.4	6 41	+ 13.0	+ 1.9	58.5	14.5	19 40	cl, st, w	
423	24	11 42	ψ Vir	4.9	12 50	— 9.1	— 1.1	48.0	13.5	19 45	cl, st, l w	
424	March 1	11 47	»	»	»	»	— 1.0	48.5	11.5	19 50	cl, st, l w	
425	4	11 59	»	»	»	»	— 0.9	48.5	10.5	19 50	cl, v st, c	
426	17	8 23	x Hyd	5.0	9 37	— 14.0	— 1.2	43.0	20.5	19 10	cl, f st, str w	
427	19	9 47	ψ Vir	4.9	12 50	— 9.1	— 3.0	32.0	15.0	19 30	cl, unst, str w	r uneven
428	20	9 51	»	»	»	»	— 3.0	32.0	16.0	19 20	cl, f st, w	
429	21	9 55	»	»	»	»	— 2.9	33.0	16.5	19 20	cl, r unst, w	
430	24	9 07	α Hyd	2.2	9 24	— 8.3	— 0.3	51.0	24.0	18 50	r th, r unst, c	
431	29	9 57	IC 2627	—	11 07	— 23.5	— 1.2	33.5	22.5	19 05	r th, f st, str w	Silvering
432	Apr 15	10 33	γ Vir	2.9	12 38	— 1.0	— 2.1	47.0	20.0	19 00	cl, f st, w	
433	16	10 52	»	»	»	»	— 1.8	49.5	19.0	19 05	cl, f st, w	
434	17	10 41	»	»	»	»	— 2.0	48.0	19.5	18 40	cl, f st, v str w	
435	18	11 15	»	»	»	»	— 1.4	52.5	19.5	19 00	cl, f st, l w	
436	20	11 23	»	»	»	»	— 1.3	53.0	27.0	18 35	cl, f st, str w	
437	23	11 05	»	»	»	»	— 1.5	52.0	21.0	19 00	cl, st, w	
438	27	11 51	δ Crt	3.8	11 15	— 14.4	+ 0.6	44.5	18.0	19 15	cl, f st, r w	
439	28	11 35	β Crv	2.8	12 30	— 23.0	— 0.9	35.0	20.5	18 55	cl, f st, w	
440	29	11 39	δ Crv	3.1	12 26	— 16.1	— 0.8	42.5	21.0	18 55	cl, unst, w	
441	30	12 13	γ Vir	2.9	12 38	— 1.0	— 0.4	58.0	23.0	18 50	cl, f st, w	
442	May 1	14 07	ξ ² Lib	5.6	14 53	— 11.1	— 0.8	47.5	22.5	19 22	cl, st, v str w	
443	6	16 52	μ Ser	3.6	15 46	— 3.2	+ 1.1	52.0	19.0	19 50	cl, st, l w	
444	13	11 08	γ Vir	2.9	12 38	— 1.0	— 1.5	52.0	24.0	18 40	cl, unst, w	
445	14	12 12	»	»	»	»	— 0.4	58.0	22.5	18 50	cl, st, w	
446	17	12 09	»	»	»	»	— 0.5	58.0	30.0	18 40	cl, unst, w	
447	18	12 43	»	»	»	»	+ 0.1	59.0	28.0	18 50	cl, unst, w	
448	20	12 35	»	»	»	»	— 0.0	59.0	27.0	18 50	cl, f st, s w	
449	21	12 24	2 Lib	6.3	14 19	— 11.4	— 1.9	41.0	23.5	19 10	cl, st, l w	
450	22	13 13	m Vir	5.2	13 38	— 8.3	— 0.4	51.0	24.0	18 55	cl, f st, w	
451	23	13 17	ζ Vir	3.4	13 31	— 0.2	— 0.2	59.5	26.0	18 50	cl, f st, w	
452	25	14 10	2 Lib	6.3	14 19	— 11.4	— 0.1	48.5	23.5	19 25	cl, f st, l w	
453	28	13 07	»	»	»	»	— 1.2	45.0	26.5	18 40	clouds, f st, w	
454	June 18	13 45	γ Vir	2.9	12 38	— 1.0	+ 1.1	54.5	30.0	18 35	cl, unst, str w	
455	19	15 19	»	»	»	»	+ 2.7	40.0	30.0	18 45	cl, f st, w	
456	20	15 08	»	»	»	»	+ 2.5	41.5	33.0	18 30	cl, f st, s w	
457	22	15 31	»	»	»	»	+ 2.9	38.0	27.0	19 00	cl, f st, w	
458	23	15 35	ε Sco	2.4	16 45	— 34.2	— 1.2	23.5	26.0	18 45	cl, f st, w	v patchy
459	July 14	16 27	»	»	»	»	— 0.3	25.5	30.5	18 45	cl, st, w	
460	17	16 24	»	»	»	»	— 0.4	25.5	32.5	18 35	cl, unst, str w	unst
461	24	17 07	γ Sgr	3.1	18 01	— 30.4	— 0.9	28.5	33.5	18 35	cl, r unst, str w	
462	Aug 13	17 26	η Sgr	3.2	18 12	— 36.8	— 0.8	22.0	32.0	18 40	cl, r unst, w	unst
463	14	18 30	»	»	»	»	+ 0.3	23.0	33.5	18 40	cl, r unst, w	

No	Date	L.S.T.	Object	<i>m</i>	α	δ	<i>h</i>	Alt.	<i>T</i>	<i>CH</i>	Weather	Remarks
464	Aug 16	18 38	η Sgr	3.2	18 12	— 36°8	+ 0.4	23°0	34°0	18; 50	cl, st, w	Silvering
465	1922 17	18 27	"	"	"	"	+ 0.2	23.0	34.5	18 45	cl, f st, w	
466	19	18 50	"	"	"	"	+ 0.6	22.5	31.0	18 55	cl, f st, w	
467	Jan 1	1 59	ζ Cet	3.9	1 48	— 10.7	+ 0.2	49.0	18.5	19 35	c, l cloud	
468	1927 2	2 03	"	"	"	"	+ 0.2	49.0	17.0	19 40	cl, g	Silvering
469	3	1 08	"	"	"	"	— 0.7	42.0	18.0	19 40	cloudy	
470	5	1 47	θ Cet	3.8	1 20	— 8.6	+ 0.4	51.0	18.0	19 35	thin m, w	
471	6	2 21	α Cet	var	2 16	— 3.3	+ 0.1	57.0	16.0	19 40	thin m	
472	7	3 25	β For	4.5	2 46	— 32.7	+ 0.6	27.0	14.0	19 35	cl, v unst	
473	8	4 45	γ C Ma	4.1	7 00	— 15.5	— 2.2	34.0	12.0	19 45	f st, sl w	
474	30	3 33	Com. Grigg-Skj.	—	6 09	— 13.9	— 2.6	32.0	16.0	19 30		
475	31	3 22	"	—	6 08	— 13.8	— 2.8	31.0	16.0	19 35	w	
476	Febr 3	3 50	"	—	6 03	— 13.7	— 2.2	37.0	18.0	19 30	unst, sl w	
477	4	4 24	"	—	6 02	"	— 1.6	41.0	15.0	19 35	sl w	
478	20	4 42	$\times$ Ori	2.2	5 44	— 9.7	— 1.0	47.5	20.0	18 55	cl	
479	25	5 46	Com. Grigg-Skj.	—	5 39	— 11.7	+ 0.1	48.5	17.0	19 30	th clouds, w	
480	26	6 50	"	—	"	— 11.6	+ 1.2	45.0	14.0	19 40	r w	
481	27	5 23	$\times$ Ori	2.2	5 44	— 9.7	— 0.3	49.5	17.0	19 25		
482	28	5 27	"	"	"	"	— 0.3	49.5	19.0	19 20		
483	March 2	5 50	"	"	"	"	+ 0.1	50.0	19.0	19 25		
484	3	5 38	"	"	"	"	— 0.1	50.0	23.0	19 15		
485	6	7 20	"	"	"	"	+ 1.6	43.5	17.0	19 35	l cloudy	
486	11	12 08	ϕ Vir	4.9	12 51	— 9.1	— 0.7	49.5	16.0	20 00	r unst	
487	12	12 42	μ Cen	3.3	13 45	— 42.1	— 1.0	16.5	17.0	20 10		
488	23	7 42	ζ Ori	2.0	5 37	— 2.0	+ 2.1	46.5	21.0	19 35	sl w	
489	24	7 16	"	"	"	"	+ 1.6	49.5	19.0	19 35		
490	26	7 48	"	"	"	"	+ 2.2	45.0	20.5	19 28	w	
491	29	8 14	η Ori	3.4	5 21	— 2.5	+ 2.9	37.0	24.5	19 15	clouds	
492	30	8 48	"	"	"	"	+ 3.5	30.0	22.0	19 35	m	
493	Apr 1	8 25	ζ Ori	2.0	5 37	— 2.0	+ 2.8	38.5	21.0	19 40		
494	25	9 53	ζ Hyd	3.3	8 52	+ 6.2	+ 1.0	62.0	26.0	19 25	v unst, v w	Silvering
495	30	11 12	ϕ Vir	4.9	12 51	— 9.1	— 1.6	45.0	23.5	19 35	th m, sl w	
496	May 2	10 50	γ Vir	2.9	12 38	— 1.1	— 1.8	49.0	26.0	19 25		
497	3	10 54	ϕ Vir	4.9	12 51	— 9.1	— 1.9	42.5	26.5	19 25	w	
498	4	12 57	θ Vir	4.4	13 06	— 5.2	— 0.2	55.0	23.5	19 50		
499	8	15 03	π Sco	3.0	15 54	— 25.9	— 0.8	32.5	22.5	20 10	l m	
500	9	16 17	ν Oph	3.5	17 55	— 9.8	— 1.6	44.0	21.0	20 20	r m	
501	22	13 53	π Vir	4.6	11 57	+ 7.0	+ 1.9	54.5	26.5	19 42	r m	
502	27	14 48	"	"	"	"	+ 2.8	43.5	22.4	19 55	m, v w	
503	29	13 36	94 Vir	6.6	14 02	— 8.5	— 0.4	51.0	24.0	19 20		
504	June 19	14 18	$\times$ Vir	4.3	14 09	— 9.9	+ 0.2	50.0	29.5	19 32		
505	20	14 37	π Hyd	3.5	14 02	— 26.3	+ 0.6	32.5	30.5	19 30	m, w	
506	24	14 54	β Lib	2.7	15 13	— 9.1	— 0.3	51.0	31.5	19 22	m, w	
507	July 4	17 55	ν Oph	3.5	17 55	— 9.8	+ 0.0	50.0	31.5	19 40		
508	5	18 39	4 H Set	4.7	18 38	— 9.1	+ 0.0	51.0	30.0	19 15	m	
509	8	19 47	ϵ Aqr	3.8	20 44	— 9.8	— 0.9	49.0	27.8	19 50	unst	
510	9	19 51	θ Aql	3.4	20 08	— 1.0	— 0.3	59.0	25.0	19 52		
511	11	20 25	λ Aql	3.6	19 02	— 5.0	+ 1.4	49.0	25.5	20 20	v unst	
512	12	20 38	θ Aql	3.4	20 08	— 1.0	+ 0.5	58.0	26.5	20 05	st	
513	19	15 51	β Sco	2.9	16 01	— 19.6	— 0.2	40.0	34.0	19 22		
514	20	16 40	θ Oph	3.4	17 18	— 24.9	— 0.6	34.0	32.2	19 32	r m	
515	21	16 59	"	"	"	"	— 0.3	35.0	29.0	19 40		
516	22	17 03	"	"	"	"	— 0.2	35.0	28.5	19 40	m	
517	25	16 30	IC 4601	—	16 12	— 19.5	+ 0.3	40.0	33.0	19 20		
518	26	16 19	β Sco	2.9	16 01	— 19.6	+ 0.3	40.0	34.5	19 17	st	
519	Aug 20	16 39	γ Sgr	5.1	19 54	— 15.7	— 3.2	21.5	33.0	19 25		
520	21	16 43	μ Sgr	4.0	18 09	— 21.1	— 1.4	35.0	35.5	19 10	v unst, str w	
521	Sept 17	19 06	γ Mic	4.7	20 57	— 32.5	— 1.8	22.0	28.8	19 20	v unst, r w	
522	18	20 55	γ Gru	3.2	21 50	— 37.7	— 0.9	21.0	29.0	19 22		
523	19	20 29	"	"	"	"	— 1.4	19.0	30.0	19 20	unst	
524	20	20 33	"	"	"	"	— 1.3	20.0	29.0	19 25		
525	21	20 52	"	"	"	"	— 1.0	20.5	30.0	19 30		

No	Date	L.S.T.	Object	<i>m</i>	α	δ	<i>h</i>	Alt.	<i>T</i>	<i>CH</i>	Weather	Remarks
		<i>h m</i>		<i>m</i>	<i>h m</i>		<i>h</i>					
526	Sept 22	19 09	ι Sgr	4.2	19 50	— 42°1	— 0.7	17°5	28°0	19; 30		
527	1927 25	21 20	27 Psc	5.1	23 55	— 4.0	— 2.6	39.0	29.5	19 30	r m, w	
528	26	21 24	NGC 7307	—	22 30	— 41.3	— 1.1	17.5	26.0	19 30		
529	27	21 58	ι Phe	4.8	23 31	— 43.0	— 1.6	13.5	27.0	19 40	sl m, w	
530	29	21 32	γ Gru	3.2	21 50	— 37.7	— 0.3	22.0	27.0	19 40	unst	
531	30	22 08	ι Cet	3.8	0 16	— 9.2	— 2.1	41.0	26.0	19 50		
532	Oct 4	23 53	12 Cet	6.0	0 26	— 4.4	— 0.6	54.5	24.0	19 52		
533	19	20 17	γ Gru	3.2	21 50	— 37.7	— 1.6	18.5	27.5	19 30	extr unst, str w	
534	20	21 51	27 Psc	5.1	23 55	— 4.0	— 2.1	45.0	28.0	19 25	str w	
535	30	22 30	ι Cet	3.8	0 16	— 9.2	— 1.8	43.5	23.5	20 05	cl, str w	
536	31	0 34	ζ Cet	3.9	1 48	— 10.7	— 1.2	46.0	22.0	20 00	l unst	
537	Nov 2	1 42	δ Cet	4.0	2 36	+ 0.0	— 0.9	57.0	21.5	20 10	cl, unst	
538	6	4 57	NGC 2938	—	9 38	+ 76.9	— 4.7	34.0	16.5	20 08		
539	7	5 46	30 Mon	4.0	8 22	— 3.7	— 2.6	40.0	19.5	20 15	w	
												Silvering
540	20	22 24	α Scl	4.4	0 55	— 29.7	— 2.5	21.0	21.5	19 48	w	
541	22	23 03	72 Psc	5.7	1 01	+ 14.6	— 1.0	69.0	23.5	18 55	v w	
542	24	21 56	h Sgr	4.7	19 32	— 25.0	+ 2.4	25.0	23.2	19 45	cl, w	
543	25	22 00	ψ Sgr	4.9	19 11	— 25.4	+ 2.8	21.5	23.5	19 00	v unst, w	
544	26	22 04	γ Sgr	3.1	18 01	— 30.4	+ 4.0	7.0	24.0	19 52	extr unst	
545	Dec 12	22 59	π Sgr	3.0	19 05	— 21.1	+ 3.9	13.0	19.5	19 52		
546	15	23 12	»	»	»	»	+ 4.1	11.5	19.5	19 50	cl	
547	19	23 30	β Cap	3.3	20 17	— 15.0	+ 3.2	25.5	19.0	19 50	st	
548	25	1 27	o Cet	var	2 16	— 3.3	— 0.8	54.0	18.0	19 45	f st	
549	27	2 51	φ Eri	3.8	2 14	— 51.9	+ 0.6	8.0	18.0	20 00	n v cl, r w	
550	Jan 12	2 06	ϵ Eri	3.8	3 30	— 9.7	— 1.4	45.5	20.5	19 45	cl, l m, st	
551	1928 18	2 02	κ For	5.4	2 19	— 24.1	— 0.3	36.0	17.0	19 00	unst	
552	19	2 31	NGC 1353	—	3 29	— 21.1	— 1.0	37.5	18.0	18 55	cl, c	
553	21	2 39	NGC 1359	—	3 31	— 19.7	— 0.9	38.5	17.0	18 58	extr unst	
554	24	3 07	τ^b Eri	4.3	3 31	— 21.9	— 0.4	38.0	17.0	18 58	v unst, w	
555	26	5 16	α C Ma	— 1.6	6 42	— 16.6	— 1.4	38.5	16.0	18 58	extr unst, v w	
556	Febr 9	4 43	β Ori	0.3	5 11	— 8.3	— 0.5	51.0	14.0	19 05	r unst, v w	
557	10	4 17	μ Eri	4.2	4 42	— 3.4	— 0.4	56.0	18.0	19 03	c	
558	13	4 29	»	»	»	»	— 0.2	57.0	19.0	19 05	st	
559	15	4 51	»	»	»	»	+ 0.2	57.0	18.5	18 50	st, sl w	
560	17	7 59	α Hyd	2.2	9 24	— 8.3	— 1.4	46.0	14.0	19 10	st, c	
561	18	7 33	»	»	»	»	— 1.9	42.0	15.5	19 02	v unst	
562	March 11	7 41	30 Mon	4.0	8 22	— 3.7	— 0.7	55.0	20.0	18 45	r unst, r w	
563	12	8 15	α Hyd	2.2	9 24	— 8.3	— 1.1	48.5	22.0	18 45	h, sl w	
564	14	8 23	»	»	»	»	— 1.0	48.5	20.0	18 55	w	
												Silvering
565	Apr 15	9 19	»	»	»	»	— 0.1	51.5	27.5	18 35	sl h, v w	
566	Aug 14	17 53	α Cr A	4.1	19 05	— 38.0	— 1.2	20.0	32.0	18 32	f st	
567	26	23 05	ι Phe	4.8	23 31	— 43.0	— 0.4	17.0	27.5	19 20	r h, r unst	
568	Sept 3	20 19	α Cr A	4.1	19 05	— 38.0	+ 1.2	19.0	31.0	19 00	w	
569	4	20 23	»	»	»	»	+ 1.3	19.0	29.0	18 40	w	
570	9	18 25	»	»	»	»	— 0.7	21.0	30.0	18 45	cl, c	
571	11	18 48	»	»	»	»	— 0.3	21.5	30.0	18 48	v unst	
572	12	18 52	»	»	»	»	— 0.2	21.5	31.0	18 48	v unst, v w	
573	14	19 00	»	»	»	»	— 0.1	22.0	29.5	18 50		
574	15	19 13	»	»	»	»	+ 0.1	22.0	28.0	19 00		
575	16	19 17	»	»	»	»	+ 0.2	22.0	29.5	18 50		
576	17	19 36	»	»	»	»	+ 0.5	21.5	29.0	18 50	unst, w	
577	22	22 42	ι Phe	4.8	23 31	— 43.0	— 0.8	16.0	26.0	19 20	unst	
578	Oct 7	21 06	γ Gru	3.2	21 50	— 37.7	— 0.7	21.5	25.0	19 05		
579	8	21 25	NGC 7307	—	22 30	— 41.3	— 1.1	17.5	25.0	19 05	sl w	
580	10	21 17	γ Gru	3.2	21 50	— 37.7	— 0.5	22.0	24.5	19 05	w	
581	11	21 21	ι Phe	4.8	23 31	— 43.0	— 2.2	10.0	24.0	19 10		
582	12	19 55	ι Sgr	4.2	19 50	— 42.1	+ 0.1	18.0	26.5	18 45		
												Silvering
583	Nov 11	21 21	α Aqr	3.2	22 02	— 0.7	— 0.7	58.0	27.0	18 15	st, r w	
584	12	0 10	20 Cet	4.9	0 49	— 1.5	— 0.7	57.5	23.0	18 45		
585	26	8 53	β Crv	2.8	12 31	— 23.0	— 3.6	15.5	12.0	19 40		

No	Date	L.S.T.	Object	<i>m</i>	α	δ	<i>h</i>	Alt.	<i>T</i>	<i>CH</i>	Weather	Remarks
		<i>h m</i>		<i>m</i>	<i>h m</i>		<i>h</i>					
586	Jan 5	2 34	τ^5 Eri	4.3	3 31	— 21°9	— 1.0	36°5	18°5	18; 42	v w	
587	1929	5 32	$\times$ Ori	2.2	5 44	— 9.7	— 0.2	50.0	14.5	19 10	cl, st	
588	14	4 28	ι Ori	2.9	5 32	— 6.0	— 1.1	50.5	11.0	18 45	cl, unst	
589	Febr 5	6 15	β CMa	2.0	6 20	— 17.9	— 0.1	42.0	11.0	19 07	cl	
590	7	4 53	$\times$ Ori	2.2	5 44	— 9.7	— 0.9	48.0	15.5	18 45		
591	11	7 24	σ^2 CMa	3.1	7 00	— 23.7	+ 0.4	35.5	13.5	19 00		
592	14	8 35	α Hyd	2.2	9 24	— 8.4	— 0.8	50.0	14.0	18 52	unst, sl w	
593	17	10 32	ξ Hyd	3.7	11 30	— 31.5	— 1.0	27.0	12.0	19 00	st	gradual
594	March 4	7 44	α Pup	5.0	8 10	— 15.6	— 0.4	44.5	14.0	19 02	cl, st	
595	5	8 18	$\times$ Hyd	5.0	9 37	— 14.0	— 1.3	41.5	16.0	18 45	lh, unst	
596	Apr 1	9 56	ξ Hyd	3.7	11 30	— 31.5	— 1.6	24.0	18.0	18 40	r unst	
597	2	10 15	NGC 4030	—	11 55	— 0.5	— 1.7	51.0	19.0	18 37	unst, w	
598	3	9 34	ν Hyd	3.3	10 46	— 15.8	— 1.2	41.0	20.0	18 37	v w	
599	10	9 59	β Crt	4.5	11 08	— 22.4	— 1.2	35.0	17.0	18 47	w	Silvering
600	May 1	10 48	ν Leo	4.5	11 33	— 0.4	— 0.8	57.5	29.0	19 09		
601	7	12 11	ν Vir	4.2	11 42	+ 6.9	+ 0.5	65.0	30.0	19 15	h, w	
602	8	12 15	θ Vir	4.5	13 06	— 5.2	— 0.8	53.0	27.5	19 08		
603	June 3	14 59	δ Sco	2.5	15 56	— 22.4	— 1.0	36.0	28.0	19 35	w	
604	July 18	21 44	γ Gru	3.2	21 50	— 37.7	— 0.1	22.0	24.0	20 07	m, st	
605	Sept 26	19 26	θ Cap	4.2	21 02	— 17.5	— 1.6	38.0	35.3	18 45		
606	30	21 55	Com 1929 (b)	5.5	21 16	— 15.8	+ 0.6	43.5	24.0	19 20	v m, v w	
607	Oct 9	21 56	δ Scl	4.6	23 45	— 28.5	— 1.8	26.5	23.5	19 25	unst, w	
608	28	21 10	α Aqr	3.2	22 02	— 0.7	— 0.9	57.0	28.0	19 08	w	
609	29	21 14	α PsA	1.3	22 54	— 30.0	— 1.7	25.5	26.0	19 10	unst	
610	30	21 18	ι Phe	4.8	23 31	— 43.0	— 2.2	10.0	28.2	19 07	cloudy	Silvering
611	Nov 23	2 38	π Cet	4.4	2 41	— 14.2	— 0.0	46.0	20.0	19 05	l cloudy	
612	25	22 31	δ Scl	4.6	23 45	— 28.5	— 1.2	29.5	22.0	18 45	unst, v w	
613	Dec 3	23 32	ι Cet	3.75	0 16	— 9.2	— 0.8	49.0	20.0	18 45	extr unst, v w	
614	28	1 11	α Scl	4.4	0 55	— 29.7	+ 0.3	30.0	15.0	18 50	v unst, w	
615	30	1 19	ζ Cet	3.9	1 48	— 10.7	— 0.5	48.5	16.0	18 55	cloudy	
616	Jan 18	2 24	α Aqr	3.2	22 02	— 0.7	+ 4.4	20.0	16.0	19 00		
617	1930	5 25	Ori-field	—	5 37	— 2.0	— 0.2	58.0	14.0	19 02		
618	March 19	9 00	δ Gem	3.5	7 16	+ 22.1	+ 1.7	66.0	22.5	19 00	r unst	
619	24	9 20	"	"	"	"	+ 2.1	61.0	20.0	20 05	cl, sl w	pr gradual
620	27	10 02	"	"	"	"	+ 2.8	51.5	21.3	19 22		
621	29	9 55	"	"	"	"	+ 2.7	53.0	18.0	19 25	cl, f st	
622	31	9 38	"	"	"	"	+ 2.4	57.0	18.0	19 20	v unst, v w	
623	Apr 19	10 02	"	"	"	"	+ 2.8	51.0	24.3	19 20	sl m, w	
624	20	10 26	"	"	"	"	+ 3.2	46.5	23.0	19 15	g seeing	
625	25	10 14	"	"	"	"	+ 3.0	48.5	22.0	19 00	st, g seeing	
626	26	9 48	"	"	"	"	+ 2.5	55.0	23.5	19 10	sl w	
627	27	9 52	"	"	"	"	+ 2.6	53.5	24.0	19 10	sl w	
628	28	10 11	"	"	"	"	+ 2.9	50.0	26.5	19 15	m, sl cloudy	
629	29	10 12	"	"	"	"	+ 2.9	50.0	31.0	19 25	sl h	
630	30	11 16	"	"	"	"	+ 4.0	36.0	32.0	19 10	cl, v unst	Silvering
631	May 14	11 11	"	"	"	"	+ 3.9	37.0	30.0	20 08	r m, w	
632	15	11 15	"	"	"	"	+ 4.0	36.0	26.5	20 30	m, w	
633	16	11 19	"	"	"	"	+ 4.0	36.0	30.0	20 50	w	
634	17	11 23	"	"	"	"	+ 4.1	34.0	30.0	20 10	h, unst, w	
635	20	11 35	"	"	"	"	+ 4.3	31.5	25.0	20 25	w	
636	24	11 51	"	"	"	"	+ 4.6	28.0	26.0	20 10	w	
637	25	11 55	"	"	"	"	+ 4.6	28.0	30.0	19 55	unst, w	
638	26	11 59	"	"	"	"	+ 4.7	27.0	32.0	20 05	unst, w	
639	27	12 03	"	"	"	"	+ 4.8	25.5	31.5	20 05	sl h, v unst, w	
640	28	12 12	"	"	"	"	+ 4.9	24.0	32.5	20 10		
641	June 21	14 11	θ Cen	2.3	14 03	— 36.0	— 0.1	24.0	31.0	20 15		
642	22	14 15	"	"	"	"	— 0.2	24.0	34.0	20 05	h, v unst, E w	
643	23	14 19	γ Hyd	3.3	13 15	— 22.8	— 1.1	35.0	30.5	20 45		
644	24	14 23	"	"	"	"	+ 1.1	35.0	28.0	20 05	h at hor., w	
645	25	14 27	"	"	"	"	+ 1.2	34.5	30.0	20 20	w	
646	26	14 31	"	"	"	"	+ 1.3	34.0	30.0	20 10	sl h, unst, w	

No	Date	L.S.T.	Object	<i>m</i>	α	δ	<i>h</i>	Alt.	<i>T</i>	<i>CH</i>	Weather	Remarks
		<i>h m</i>		<i>m</i>	<i>h m</i>		<i>h</i>					
647	June 28	15 08	θ Cen	2.3	14 03	-36°0	+1.1	22°0	30°0	20; 15		pr gradual
648	1930 29	15 42	β Lib	2.7	15 13	-9.1	+0.5	50.0	29.0	20 25	st, w	
649	30	16 01	ε Sco	2.4	16 46	-34.2	-0.7	25.0	29.0	20 10		v gradual
650	July 19	16 01	ζ Oph	2.7	16 33	-10.4	-0.5	49.0	32.5	20 10	cl, sl w	
651	21	16 39	ν Sco	2.8	17 26	-37.2	-0.8	22.0	32.5	20 15	h, sl w	
652	22	16 13	α Lib	2.9	14 47	-15.8	+1.4	41.0	32.5	20 20	h, unst, sl w	
653	23	16 32	γ Sco	3.4	15 00	-25.0	+1.5	31.0	31.5	20 10	sl h	
654	24	17 21	η Oph	2.6	17 06	-15.6	+0.3	44.5	32.0	20 20	h, r unst, w	
655	25	16 25	Lib	—	15 10	-14.2	+1.3	42.0	34.5	20 05	sl h	
656	26	16 44	ν Oph	3.5	17 55	-9.8	-1.2	46.5	35.0	20 05	r h, sl w	
657	27	16 33	δ H Sct	4.7	18 38	-9.1	-2.1	41.0	35.0	20 05	cl, unst, w	
658	29	17 41	μ Sgr	4.0	18 10	-21.1	-0.5	38.0	30.5	20 30	c	
659	Aug 5	21 04	γ Gru	3.2	21 50	-37.7	-0.7	21.5	29.5	20 45	m, v unst	
660	16	17 52	α CrA	4.1	19 05	-38.0	-1.2	19.5	33.0	20 10	sl h, sl unst	
661	18	18 00	η Sgr	3.2	18 13	-36.8	-0.2	23.0	31.0	20 05	unst, v w	
662	19	18 34	"	"	"	"	+0.3	22.5	29.5	20 05	sl unst, w	
663	21	18 15	"	"	"	"	+0.0	23.0	31.0	20 15	unst	
664	22	18 19	"	"	"	"	+0.1	23.0	32.5	20 15	unst, w	
665	23	18 23	"	"	"	"	+0.2	23.0	32.0	20 15	w	
666	24	19 38	"	"	"	"	+1.4	20.0	29.5	20 32	st	
667	26	18 46	"	"	"	"	+0.5	22.0	32.0	20 22	st, c	
668	27	19 35	"	"	"	"	+1.4	19.5	32.0	20 25	st	
669	Sept 13	18 42	γ Her	3.8	16 19	+19.3	+2.4	56.0	30.5	20 20		
670	14	18 46	"	"	"	"	+2.4	56.0	30.5	20 15	r w	
671	15	18 50	"	"	"	"	+2.5	54.5	31.5	20 12		
672	16	19 24	β Sco	2.9	16 01	-19.6	+3.4	20.0	29.0	20 20		
673	18	19 17	γ Her	3.8	16 19	+19.3	+3.0	48.0	29.0	20 15		
674	20	19 10	"	"	"	"	+2.9	49.0	28.0	20 15		
675	24	19 25	"	"	"	"	+3.1	46.5	28.0	20 10		
676	26	3 03	δ Gem	3.5	7 16	+22.1	-4.2	32.5	26.5	20 50	cl, f st	gradual, n even
677	27	3 07	"	"	"	"	-4.2	32.5	26.0	21 25	v w	
678	29	3 15	α^2 CMa	3.1	7 00	-23.7	-3.7	15.0	22.5	22 50	cl, st	678 and 684 are
679	Oct 27	23 35	ι Cet	3.75	0 16	-9.2	-0.7	49.0	26.5	20 35	cl, st	probably erro-
680	Nov 17	22 28	α PsA	1.3	22 54	-30.0	-0.4	29.5	20.5	20 38	m, unst	neous in whole
681	19	0 06	α Cet	var	2 16	-3.3	-2.2	44.0	20.5	20 35	m, c	revolutions
682	20	0 10	α Scl	4.4	0 55	-29.7	-0.7	29.0	19.0	20 40	cl, sl m, unst	of CH
683	22	22 18	α PsA	1.3	22 54	-30.0	-0.6	29.0	21.0	20 20	cl, sl w	
684	23	23 22	ι Cet	3.75	0 16	-9.2	-0.9	48.5	20.0	23 00	cl, unst	
685	Dec 14	0 00	20 Cet	4.9	0 49	-1.5	-0.8	56.5	19.0	20 55		Silvering
686	15	0 49	"	"	"	"	$\pm$ 0.0	58.5	18.0	20 45	cl	
687	20	0 38	θ Cet	3.8	1 21	-8.5	-0.7	50.0	21.0	20 35		
688	Jan 24	6 24	γ CMa	4.1	7 01	-15.5	-0.6	44.0	13.0	20 00		
689	1931 25	7 47	34 Sex	6.6	10 39	+3.9	-2.9	41.5	12.0	20 10		
690	Febr 9	7 16	κ Hyd	5.0	9 37	-14.0	-2.3	35.0	13.0	20 08		
691	10	7 20	"	"	"	"	-2.3	35.0	14.0	21 05		
692	March 10	9 26	μ Gem	3.2	6 19	+22.6	+3.1	48.0	18.0	20 40		
693	14	9 23	"	"	"	"	+3.1	48.0	26.5	21 00		
694	Sept 3	18 30	α CrA	4.1	19 05	-38.0	-0.6	21.5	30.0	20 28	l h	
695	6	18 26	"	"	"	"	-0.6	21.5	32.0	20 22	st	
696	7	18 45	"	"	"	"	-0.3	21.5	30.0	20 30	st	
697	8	18 34	"	"	"	"	-0.5	21.5	32.5	20 18	v w	
698	9	18 38	"	"	"	"	-0.4	21.5	31.0	20 15	l w	
699	13	18 54	"	"	"	"	-0.2	22.0	31.5	20 15	l w	
700	Oct 3	19 58	ι Sgr	4.2	19 50	-42.1	+0.1	18.0	26.5	20 30	cl, st	
701	4	20 02	γ Mic	4.7	20 57	-32.5	-0.9	26.5	28.0	20 21	v w	
702	5	20 06	γ Gru	3.2	21 50	-37.6	-1.7	18.0	32.5	20 08	r h, c	
703	7	20 14	θ' Mic	4.9	21 16	-41.1	-1.0	18.0	25.5	20 40	v w	
704	10	19 56	"	"	"	"	-1.3	16.5	27.0	20 30	st, l w	
705	11	21 30	ι Phe	4.8	23 31	-43.0	-2.0	12.0	27.0	20 32	st, v str w	r gradual
706	13	21 45	"	"	"	"	-1.8	12.5	27.0	20 25	sl h, st	
707	17	23 23	α Scl	4.4	0 55	-29.7	-1.5	27.0	23.0	20 40	v w	
708	18	0 50	"	"	"	"	-0.1	30.0	23.0	20 50	st	Silvering

No	Date	L.S.T.	Object	<i>m</i>	α	δ	<i>h</i>	Alt.	<i>T</i>	<i>CH</i>	Weather	Remarks
		<i>h m</i>		<i>m</i>	<i>h m</i>		<i>h</i>					
709	Oct 30	20 59	ϵ Cap	4.3	21 18	— 17° 1	— 0.3	43° 0	29° 0	20; 10		
710	Nov 10	22 28	δ Scl	4.6	23 45	— 28.5	— 1.3	29.0	23.0	20 00	clouds	
711	1931 11	22 06	ϵ Aqr	3.8	20 44	— 9.7	+ 1.4	50.0	23.5	20 00		
712	12	22 10	δ Scl	4.6	23 45	— 28.5	— 1.5	27.5	23.0	19 55		
713	14	0 48	π Cet	4.4	2 41	— 14.1	— 1.9	38.0	21.0	20 00	unst, v w	
714	29	22 47	δ Scl	4.6	23 45	— 28.5	— 1.0	29.0	21.0	19 50		
715	Dec 3	23 02	ϵ^3 Aqr	3.8	23 06	— 21.5	— 0.1	38.5	20.0	20 00	sl h, unst	
716	8	23 22	2 Cet	4.6	0 00	— 17.7	— 0.6	41.5	18.0	19 50	st	pr gradual
717	13	2 12	π Cet	4.4	2 41	— 14.1	— 0.5	46.0	23.0	20 10	sl h, unst	
718	Jan 10	2 47	β For	4.5	2 46	— 32.7	+ 0.0	27.5	17.0	20 10	c, seeing	
719	1932 30	3 51	"	"	"	"	+ 1.1	25.0	12.0	20 10		
720	31	7 25	22 Sex	5.4	10 14	— 7.7	— 2.8	34.0	11.0	20 30	cl, st	
721	Febr 1	7 29	"	"	"	"	— 2.8	35.0	12.5	20 32		
722	5	7 26	NGC 3384	—	10 44	+ 13.0	— 3.3	40.0	10.0	20 30	c	
723	6	6 00	1 Leo	5.3	10 46	+ 10.9	— 4.8	21.0	12.5	20 12	v st, c	
724	24	4 59	α^1 Cnc	5.2	8 52	+ 16.0	— 3.9	34.0	21.0	19 30		
725	26	5 07	83 Cnc	6.6	9 15	+ 18.0	— 4.1	33.0	20.0	20 00		
726	27	6 42	1 Leo	5.3	10 46	+ 10.9	— 4.1	30.0	18.0	20 10	cl, c, g	
727	March 3	7 16	"	"	"	"	— 3.5	38.0	15.5	20 10	v w	
728	7	6 47	"	"	"	"	— 4.0	31.0	25.5	20 05		
729	25	7 58	20 Pup	5.0	8 10	— 15.6	— 0.2	44.5	18.2	20 15	r h, sl w	
730	27	9 16	α Ant	4.4	10 24	— 30.7	— 1.1	27.5	22.0	20 20	r h	
731	Apr 5	9 26	1 Leo	5.3	10 46	+ 10.9	— 1.3	63.0	25.0	19 50	unst, v w	pr gradual
732	6	10 15	α Ant	4.4	10 24	— 30.7	— 0.1	29.0	25.0	20 20	v w, $\frac{1}{2}$ cloudy	
733	8	9 38	δ Boo	3.5	15 13	+ 33.6	— 5.6	20.5	26.5	19 20		
734	9	10 27	"	"	"	"	— 4.8	31.5	21.0	20 25		
735	10	12 01	ψ Vir	4.9	12 51	— 9.2	— 0.8	48.5	17.0	20 45	clouds	
736	24	12 26	β Crv	2.8	12 31	— 23.0	— 0.1	37.0	21.5	19 30		Silvering
737	27	12 58	δ Leo	2.6	11 11	+ 20.9	+ 1.8	63.0	19.0	18 20	cl	
738	May 22	12 17	β Crv	2.8	12 31	— 23.0	— 0.2	37.0	23.0	18 45		
739	23	11 51	22 Sex	5.4	10 14	— 7.7	+ 1.6	46.0	27.0	19 35		
740	24	11 55	"	"	"	"	+ 1.7	45.5	29.0	19 30	sl w	
741	25	11 59	1 Leo	5.3	10 46	+ 10.9	+ 1.2	64.0	29.5	19 30	sl w	
742	26	12 33	θ Vir	4.5	13 06	— 5.2	— 0.5	54.5	27.5	19 25	clouds	
743	28	12 26	"	"	"	"	— 0.7	54.0	32.0	19 32		
744	31	13 52	ζ Vir	3.4	13 31	— 0.3	+ 0.3	59.5	31.5	19 00	h, dusty, v w	
745	June 4	13 23	Vir	—	13 00	— 5.0	+ 0.4	54.5	30.0	19 40	sl w	
746	5	14 12	θ Vir	4.5	13 06	— 5.2	+ 1.1	50.5	30.5	19 40	thin h, cloudy	
747	6	15 06	α Lib	2.9	14 47	— 15.8	+ 0.3	44.5	30.0	19 42	v w	pr gradual
748	20	13 41	ψ Vir	4.9	12 51	— 9.2	+ 0.8	49.0	29.5	19 00	w	
749	21	14 45	η Cen	2.65	14 31	— 41.9	+ 0.2	18.0	29.0	18 55	sl w	pr gradual
750	23	13 53	μ Cen	3.3	13 46	— 42.1	+ 0.1	18.0	28.0	18 45	sl w	
751	25	14 01	γ Hyd	3.3	13 15	— 22.8	+ 0.8	36.5	33.5	18 38	sl w	
752	26	14 35	θ Vir	4.5	13 06	— 5.2	+ 1.5	48.5	32.0	18 48	r h, w	
753	27	14 09	γ Hyd	3.3	13 15	— 22.8	+ 0.9	36.0	30.0	18 58	sl w	
754	28	14 13	α Vir	1.2	13 22	— 10.8	+ 0.8	48.0	30.5	18 55		
755	30	14 21	m Vir	5.2	13 38	— 8.4	+ 0.7	50.0	31.0	18 43		
756	July 2	14 43	"	"	"	"	+ 1.1	48.5	29.0	18 55		
757	30	18 49	α CrA	4.1	19 05	— 38.0	— 0.3	22.0	29.0	19 30	unst	
758	Aug 17	23 14	α Phe	2.4	0 23	— 42.7	— 1.1	18.0	25.5	19 50		
759	24	18 24	α CrA	4.1	19 05	— 38.0	— 0.7	21.0	32.0	19 55		
760	28	18 43	"	"	"	"	— 0.4	21.5	31.5	20 05	unst, cloudy	
761	29	18 47	"	"	"	"	— 0.3	22.0	30.5	20 10	w	
762	Sept 21	20 18	λ Aqr	3.8	22 49	— 7.9	— 2.5	38.0	27.5	19 05	c, g seeing	
763	26	19 37	θ Aqr	4.3	22 13	— 8.1	— 2.6	37.5	29.0	18 55	v unst, w	bad seeing
764	Oct 1	20 12	μ And	3.9	0 53	+ 38.1	— 4.7	33.0	28.0	19 35		
765	2	20 01	"	"	"	"	— 4.9	29.0	27.0	19 30	still	
766	3	21 05	"	"	"	"	— 3.8	42.0	27.0	19 00	sl h, still night	
767	Dec 3	1 35	"	"	"	"	+ 0.7	78.0	14.5	20 15		Silvering
768	Febr 19	6 43	γ CMa	4.1	7 01	— 15.5	— 0.3	44.5	19.0	21 10		
769	1933 20	6 17	"	"	"	"	— 0.7	43.5	18.0	20 55	w	
770	24	5 48	ζ Ori	2.05	5 37	— 2.0	+ 0.2	61.5	18.5	20 52	sl h, w	

No	Date	L.S.T.	Object	<i>m</i>	α	δ	<i>h</i>	Alt.	<i>T</i>	<i>CH</i>	Weather	Remarks
		<i>h m</i>		<i>m</i>	<i>h m</i>		<i>h</i>					
771	March 23	10 19	22 Sex	5.4	10 14	— 7°7	+ 0.1	52°5	19°0	21; 09	v unst	pr gradual
772	1933 26	9 51	»	»	»	»	— 0.4	52.0	18.0	21 05	v unst	
773	29	10 13	α Hyd	2.2	9 24	— 8.4	+ 0.8	49.5	18.5	21 05	v unst	
774	July 11	15 48	σ Sco	3.1	16 17	— 25.4	— 0.5	34.0	29.0	20 30		
775	16	15 53	η Oph	2.6	17 07	— 15.6	— 1.2	41.5	32.5	20 28		
776	17	19 26	α CrA	4.1	19 05	— 38.0	+ 0.3	21.5	29.0	20 05	v unst	
777	18	16 00	α Vir	1.2	13 22	— 10.8	+ 2.6	35.0	34.0	20 10	c	
778	19	16 04	ψ Vir	4.9	12 51	— 9.2	+ 3.2	29.5	33.0	20 00	sl w	
779	23	18 20	α CrA	4.1	19 05	— 38.0	— 0.7	21.0	26.3	21 05	sl h	
780	24	17 24	»	»	»	»	— 1.7	18.0	28.3	20 50	cl, st	
781	Aug 19	17 14	»	»	»	»	— 1.9	17.0	29.0	20 50		Silvering
782	Febr 9	5 58	ζ CMa	3.1	6 18	— 30.0	— 0.3	30.0	15.0	18 48		
783	1934 11	6 10	η Ori	3.4	5 21	— 2.5	+ 0.8	56.0	9.5	19 10		
784	May 1	10 21	22 Sex	5.4	10 14	— 7.7	+ 0.1	51.5	26.5	18 20	dusty, w	
785	4	11 03	ν Leo	4.5	11 34	— 0.5	— 0.5	58.5	31.5	18 15	m, c	
786	5	11 07	»	»	»	»	— 0.5	58.5	25.5	18 37	cl, lw	
787	16	13 16	NGC 3662	—	11 20	— 0.7	+ 1.9	48.0	25.5	18 10	cl	
788	July 1	14 52	ξ^2 Lib	5.6	14 53	— 11.1	— 0.0	49.0	32.2	18 10	c	
789	3	15 00	α Lib	2.9	14 47	— 15.8	+ 0.2	44.0	32.0	18 05		
790	6	16 12	α CrA	4.1	19 05	— 38.0	— 2.9	11.0	30.0	18 25	cl, lw	
791	8	17 20	»	»	»	»	— 1.7	18.0	27.0	18 50		fr inside focus fr outside focus fr inside focus fr outside focus fr inside focus fr outside focus fr inside focus fr outside focus fr inside focus fr outside focus
792	9	15 24	»	»	»	»	— 3.7	5.0	27.0	18 40	cl, c	
793	10	17 28	»	»	»	»	— 1.6	18.5	26.5	18 40	lw	
794	11	18 02	»	»	»	»	— 1.0	20.0	26.0	18 40	cl, lw	
795	13	17 40	»	»	»	»	— 1.4	19.0	28.5	18 40	cl	
796	15	17 48	»	»	»	»	— 1.3	19.0	30.5	18 30	cl, lw	
797	16	17 52	»	»	»	»	— 1.2	19.5	33.0	19 10	cl, lw	
798	18	18 15	»	»	»	»	— 0.8	21.0	29.0	18 50	cl, lw	
799	19	18 49	»	»	»	»	— 0.3	22.0	29.0	18 50	cl, lw	
800	25	22 23	27 Psc	5.1	23 55	— 3.9	— 1.5	49.5	27.0	18 50	cl, c	
801	Aug 14	19 18	α CrA	4.1	19 05	— 38.0	+ 0.2	22.0	27.4	18 12	sl cloudy	fr inside focus fr outside focus fr inside focus fr outside focus fr inside focus fr outside focus fr inside focus fr outside focus fr inside focus fr outside focus
802	»	19 23	»	»	»	»	+ 0.3	21.5	27.3	18 12		
803	»	19 31	»	»	»	»	+ 0.4	21.5	27.2	18 12		
804	»	19 36	»	»	»	»	+ 0.5	21.5	27.1	18 12		
805	»	19 40	»	»	»	»	+ 0.6	21.0	27.0	18 12		
806	»	19 51	»	»	»	»	+ 0.8	21.0	26.8	18 13		
807	»	19 59	»	»	»	»	+ 0.9	20.5	26.6	18 11		
808	»	20 07	»	»	»	»	+ 1.0	20.5	26.5	18 11		
809	»	20 11	»	»	»	»	+ 1.1	20.0	26.4	18 11		
810	»	20 19	»	»	»	»	+ 1.2	20.0	26.3	18 12		
811	15	19 07	»	»	»	»	+ 0.0	22.0	28.2	18 19	cl, st, c	
812	»	19 11	»	»	»	»	+ 0.1	22.0	28.2	18 20		
813	»	19 15	»	»	»	»	+ 0.2	22.0	28.0	18 18		
814	»	19 34	»	»	»	»	+ 0.5	21.5	27.5	18 16		
815	»	19 39	»	»	»	»	+ 0.6	21.0	27.4	18 14		
816	»	19 45	»	»	»	»	+ 0.7	21.0	27.3	18 13		
817	»	19 52	»	»	»	»	+ 0.8	21.0	27.0	18 12		
818	»	19 57	»	»	»	»	+ 0.9	20.5	26.9	18 09		
819	»	20 00	»	»	»	»	+ 0.9	20.5	26.9	18 09		
820	»	20 05	»	»	»	»	+ 1.0	20.5	26.8	18 08		
821	16	1 20	θ Cet	3.8	1 21	— 8.5	— 0.0	51.5	23.3	18 37		n ex at corner n ex at corner n ex at corner n ex at corner n ex at corner ex at corner ex at corner ex at corner ex at corner ex at corner
822	»	1 22	»	»	»	»	+ 0.0	51.5	23.4	18 41		
823	»	1 26	»	»	»	»	+ 0.1	51.5	23.4	18 40		
824	»	1 31	»	»	»	»	+ 0.2	51.5	23.4	18 41		
825	»	1 34	»	»	»	»	+ 0.2	51.5	23.4	18 43		
826	»	1 37	»	»	»	»	+ 0.3	51.0	23.3	18 40		
827	»	1 39	»	»	»	»	+ 0.3	51.0	23.3	18 40		
828	»	1 41	»	»	»	»	+ 0.3	51.0	23.3	18 43		
829	»	1 43	»	»	»	»	+ 0.4	51.0	23.3	18 40		
830	»	1 45	»	»	»	»	+ 0.4	51.0	23.3	18 42		
831	16	19 55	α Cap	3.8	20 14	— 12.8	— 0.3	46.5	27.2	18 23	cl, g	fr inside focus fr outside focus fr inside focus
832	»	20 00	»	»	»	»	— 0.2	47.0	27.2	18 21		
833	»	20 05	»	»	»	»	— 0.2	47.0	27.1	18 19		

No	Date	L.S.T.	Object	<i>m</i>	α	δ	<i>h</i>	Alt.	<i>T</i>	<i>CH</i>	Weather	Remarks
		<i>h m</i>		<i>m</i>	<i>h m</i>		<i>h</i>					
834	Aug 16	20 08	α Cap	3.8	20 14	— 12.8	— 0.1	47.0	27.0	18.18		fr outside focus
835	1934	20 15	"	"	"	"	+ 0.0	47.0	26.8	18 18		fr inside focus
836	"	20 27	ζ Cap	3.9	21 23	— 22.7	— 0.9	35.0	26.7	18 13		fr inside focus
837	"	20 33	"	"	"	"	— 0.8	35.5	26.5	18 10		fr outside focus
838	"	20 35	"	"	"	"	— 0.8	35.5	26.5	18 09		fr outside focus
839	"	20 38	"	"	"	"	— 0.8	35.5	26.4	18 11		fr inside focus
840	"	20 41	"	"	"	"	— 0.7	36.0	26.3	18 09		fr outside focus
841	"	20 53	β Cet	2.2	0 40	— 18.3	— 3.8	17.0	26.2	18 14		
842	"	20 59	"	"	"	"	— 3.7	18.0	26.2	18 13		
843	"	21 03	"	"	"	"	— 3.6	19.0	26.0	18 15		
844	"	21 05	"	"	"	"	— 3.6	19.0	26.1	18 11		rapidly done
845	"	21 08	"	"	"	"	— 3.5	20.0	26.0	18 15		
846	30	18 46	σ Sgr	2.1	18 51	— 26.4	— 0.1	33.5	30.1	18 22	cl, st	fr ins foc, n v g
847	"	18 51	"	"	"	"	$\pm$ 0.0	33.5	30.0	18 19		fr outs foc, n v g
848	"	19 02	λ Aql	3.5	19 03	— 5.0	— 0.0	55.0	29.8	18 19		fr outs foc, n g
849	"	19 06	"	"	"	"	+ 0.0	55.0	29.7	18 16		fr outs foc, f g
850	"	19 15	δ Aql	3.4	19 22	+ 3.0	— 0.1	63.0	29.4	18 14		fr ins foc, g
851	"	19 19	"	"	"	"	— 0.0	63.0	29.1	18 19		fr outs foc, f g
852	"	19 28	γ Sgr	5.0	19 54	— 15.7	— 0.4	43.5	28.5	18 16		fr outs foc, f g
853	"	19 33	54 Sgr	5.4	19 37	— 16.4	— 0.1	43.5	28.4	18 14		fr outs foc, g
854	"	19 37	"	"	"	"	$\pm$ 0.0	43.5	28.2	18 14		fr ins foc, v g
855	"	19 42	ϵ Sgr	4.2	19 51	— 42.0	— 0.2	17.5	27.8	18 17		fr outs foc, f g
856	"	19 45	"	"	"	"	— 0.1	18.0	27.8	18 14		fr ins foc, f g
857	"	19 55	θ Aql	3.4	20 08	— 1.0	— 0.2	58.5	27.6	18 12		fr outs foc, g
858	"	20 00	"	"	"	"	— 0.1	59.0	27.4	18 11		fr ins foc, g
859	"	20 04	α^2 Cap	3.8	20 14	— 12.8	— 0.2	47.0	27.3	18.12		fr ins foc, v g
860	"	20 06	"	"	"	"	— 0.1	47.0	27.0	18 11		fr outs foc, f g
861	March 11	6 54	α C Ma	— 1.6	6 42	— 16.6	+ 0.2	43.0	20.6	19 13	cl, st, w	g
862	1935	7 01	ϵ C Ma	1.6	6 56	— 28.9	+ 0.1	31.0	20.4	19 06		
863	"	7 14	α C Mi	0.5	7 36	+ 5.4	— 0.4	64.5	20.2	19 10		
864	"	7 23	α Hyd	2.2	9 24	— 8.4	— 2.0	42.0	20.1	19 07		
865	"	7 31	α Leo	1.3	10 05	+ 12.3	— 2.6	50.0	20.0	19 06		
866	"	7 38	β Leo	2.2	11 46	+ 14.9	— 4.1	31.5	19.8	19 03		
867	"	7 46	ϵ U Ma	1.7	12 51	+ 56.3	— 5.1	31.0	19.5	19 02		
868	"	8 07	α Leo	1.3	10 05	+ 12.3	— 2.0	57.0	19.2	18 52		
869	"	8 16	α Hyd	2.2	9 24	— 8.4	— 1.1	48.0	18.9	18 55		
870	"	8 29	λ Vel	2.2	9 06	— 43.2	— 0.6	16.0	18.6	18 53		
871	"	8 38	ζ Pup	2.3	8 01	— 39.8	+ 0.6	19.5	18.5	18 58		n v g
872	"	9 02	α C Mi	0.5	7 36	+ 5.4	+ 1.4	58.0	18.1	19 03		
873	"	9 08	δ C Ma	2.0	7 06	— 26.3	+ 2.0	27.5	17.8	19 08		g
874	"	9 15	α C Ma	— 1.6	6 42	— 16.6	+ 2.6	30.0	17.7	19 07		
875	"	9 23	γ Gem	1.9	6 34	+ 16.5	+ 2.8	49.5	17.8	19 08		

APPENDIX III.

CATALOGUE OF ANAGALACTIC OBJECTS PHOTOGRAPHED AT HELWAN, FOR WHICH RESOLUTION, DIMENSIONS AND TOTAL MAGNITUDE HAVE BEEN DETERMINED.

The following catalogue, on which part of the present paper is based, contains 461 anagalactic objects photographed with the 30—inch Reynolds reflector of Helwan. The measurements are made on photographs taken by H. KNOX-SHAW, C. C. L. GREGORY, M. R. MADWAR and the present writer.

The number of objects photographed by the writer amounts to about 160, for a number of them there being however replicas available, taken by the previous Helwan-observers.

In the catalogue follow in order: 1) Number of the present catalogue, 2) NGC or IC number or number in the lists of new nebulae given in the Lick Publ 8 (designated Lick), Harvard Ann 60 or 72 (designated HN) or the Helwan Bulletins (designated Helw), 3) and 4) the coordinates referred to 1900, 5) the type, in possible cases estimated as spiral (S), elliptical (E) or Magellanic Cloud (M), 6) the dimensions, 7) the total magnitude according to a) A. H. SAMAHA and b) the present writer, 8) the resolution class according to a) the present writer b) K. LUNDMARK, 9) the distance of the object from the centre of the plate and 10) the limiting magnitude of the plate.

Of the objects only NGC 4254 and NGC 4303 besides small surrounding objects are situated at positive declinations. Three »new» Helwan objects, Helw 404, 405 and 406, published in Helwan Bull 38 (1934) are found to be common with Nos. 703, 772 and 787 respectively in R. H. BAKER's list in Harvard Ann 88: 3 (1933).

No	Catalogue number	Coordinates (1900)		Type	Dimensions	Total magnitude		Resolution class		Distance from centre of plate	Limiting magnitude of plate
		α	δ			Samaha	Svenonius	Svenonius	Lundmark		
1	NGC 45	^h 008.7	— 23° 58'	—	0'3 × 0'2	^m 16.5	^m 16.8	^R 0.5	^R 0.5	13'0	^m 18.0
2		008.8	— 23 44	S	8.0 × 5.0	12.5	12.3	8.5	8.6	2.0	»
3		009.0	— 23 53.5	—	0.5 × 0.4	16.1	16.1	1.3	1.6	9.4	»
4	Helw 1	009.7	— 40 10	—	0.3 × 0.3	14.0	14.3	0.3	0.8	27.5	16.8
5	NGC 55	010.0	— 23 43.5	—	0.3 × 0.2	16.8	16.8	1.0	0.8	18.6	18.0
6		010.0	— 39 46	S	28.0 × 3.6	9.6	9.2	8.4	9.0	2.5	16.8
7		010.5	— 40 00.5	—	0.5 × 0.3	14.5	14.6	0.4	0.5	18.0	»
8		010.6	— 40 01	—	0.3 × 0.2	14.6	14.8	0.4	1.0	20.0	»
9		010.7	— 39 58.5	—	0.2 × 0.2	14.6	15.2	0.2	0.6	25.0	»
10		026.0	— 10 22	—	0.3 × 0.2	16.0	15.5	0.6	1.4	47.5	17.7
11		026.3	— 10 03.5	—	0.6 × 0.6	15.6	15.7	1.0	1.6	42.3	»
12		027.8	— 10 33.5	S	0.6 × 0.5	14.8	14.6	2.2	3.2	28.3	»
13		027.8	— 9 53	—	0.7 × 0.7	15.5	15.5	1.2	2.1	28.7	»
14		028.1	— 9 58	—	1.5 × 0.7	16.0	13.7	1.5	2.5	22.0	»
15		028.1	— 9 56.5	—	1.0 × 0.7	14.2	13.5	1.7	2.4	23.5	»
16		028.3	— 10 26.5	—	0.2 × 0.1	15.4	15.4	0.8	1.1	17.9	»
17	NGC 151	028.4	— 10 06	—	0.6 × 0.6	16.0	16.2	0.4	0.9	14.0	»
18		029.0	— 10 15	S	3.0 × 1.3	12.1	12.0	6.5	7.6	2.6	»
19		029.9	— 9 53	—	0.2 × 0.2	15.6	14.5	0.9	1.3	23.8	»

No	Catalogue number	Coordinates (1900)		Type	Dimen- sions	Total magnitude		Resolution class		Distance from centre of plate	Limiting magnitude of plate
		α	δ			Samaha	Svenonius	Svenonius	Lundmark		
		$h\ m$				m	m	R	R		m
20		0 30.0	— 9° 54'	—	0'6 × 0'2	15.1	14.7	1.6	1.9	23'4	17.7
21		0 30.0	— 10 31.5	—	0.1 × 0.1	15.6	16.7	0.2	0.4	22.0	»
22		0 30.4	— 10 18	—	0.4 × 0.2	15.8	15.5	1.1	1.1	19.0	»
23		0 30.8	— 10 37	—	0.2 × 0.2	15.4	15.9	0.4	0.8	34.7	»
24		0 30.9	— 10 39	—	0.2 × 0.2	14.5	15.5	0.7	1.0	37.9	»
25		0 31.1	— 10 27	S	1.0 × 0.6	13.9	14.2	3.5	3.4	29.8	»
26		0 31.3	— 9 56	—	0.1 × 0.1	16.0	16.4	0.6	0.7	33.6	»
27	NGC 165	0 31.4	— 10 40	—	1.0 × 0.8	13.9	14.0	1.9	2.7	42.2	»
28		0 31.5	— 10 35.5	—	0.4 × 0.4	15.6	15.2	0.8	1.4	41.8	»
29		0 31.8	— 10 24	—	0.7 × 0.3	15.6	16.0	1.3	2.2	42.0	»
30		0 40.9	— 31 47	—	0.6 × 0.5	15.8	15.7	1.0	1.2	38.3	18.2
31		0 40.9	— 21 10	—	0.6 × 0.5	13.6	13.6	1.6	2.0	18.9	17.1
32		0 41.5	— 31 24	—	0.5 × 0.5	16.7	16.0	0.5	1.3	36.0	18.2
33	NGC 247	0 42.1	— 21 18	S	19.6 × 4.9	9.7	9.8	9.1	9.2	4.9	17.1
34		0 42.4	— 31 41	—	0.3 × 0.2	16.6	16.2	0.6	0.4	21.2	18.2
35	Lick 14	0 42.5	— 20 57	S	0.9 × 0.2	13.7	13.2	2.0	2.7	16.0	17.1
36	Lick 15	0 42.6	— 21 01	—	0.4 × 0.3	14.5	14.5	1.2	1.4	13.0	»
37	Lick 17	0 42.6	— 21 03	—	0.6 × 0.2	14.0	13.7	1.7	1.8	11.0	»
38	NGC 253	0 42.6	— 25 50.5	S	24.7 × 4.8	9.7	9.6	8.9	8.9	3.0	17.8
39		0 42.9	— 31 34	E	1.3 × 0.4	13.7	13.7	1.0	2.7	16.6	18.2
40		0 43.1	— 31 17	—	0.3 × 0.2	17.0	16.1	0.6	0.6	23.9	»
41		0 43.1	— 31 38	—	0.3 × 0.3	15.7	16.0	0.5	1.0	6.5	»
42		0 43.3	— 31 46	—	0.3 × 0.3	17.0	16.1	0.7	0.7	12.5	»
43		0 43.4	— 32 06.5	—	0.4 × 0.3	17.4	16.6	0.5	0.9	17.2	»
44		0 43.4	— 31 26	—	0.2 × 0.2	17.2	16.4	0.5	0.4	35.4	»
45	{Lick 26= Helw 6 }	0 44.1	— 32 01	—	0.2 × 0.2	17.5	16.7	0.2	0.5	4.0	»
46		0 44.4	— 20 58	—	0.4 × 0.3	14.4	14.5	0.8	1.6	34.0	17.1
47		0 44.8	— 31 36	—	0.2 × 0.1	16.5	16.5	0.2	0.3	22.0	18.2
48		0 45.7	— 31 27	—	0.6 × 0.3	17.0	16.3	1.3	0.5	36.5	»
49		0 45.7	— 31 31	M	1.0 × 0.4	16.2	15.5	1.3	2.1	26.4	»
50		0 47.5	— 38 29	—	0.4 × 0.4	15.2	15.4	1.0	0.7	47.6	17.9
51		0 47.5	— 38 28.5	—	0.2 × 0.2	—	16.1	0.5	0.4	46.8	»
52		0 49.3	— 37 53	—	0.5 × 0.3	15.3	15.1	1.6	1.3	28.0	»
53		0 50.0	— 38 34.5	—	0.2 × 0.2	15.8	16.1	0.3	1.1	20.9	»
54	NGC 300	0 50.3	— 38 14	S	19.0 × 12.0	10.6	10.5	10.0	10.0	3.2	»
55		0 50.7	— 38 43	—	0.1 × 0.1	16.0	15.9	0.4	0.7	28.5	»
56		0 50.8	— 37 57.5	—	0.3 × 0.3	15.6	15.6	0.5	1.2	18.2	»
57		0 50.9	— 37 55	—	0.3 × 0.2	16.0	16.1	0.9	1.0	20.5	»
58		0 51.0	— 37 57.5	—	0.3 × 0.2	15.3	15.4	0.8	0.8	19.0	»
59		0 51.0	— 37 56	—	0.4 × 0.3	15.6	15.9	0.7	1.0	20.0	»
60		0 51.1	— 37 55.5	—	0.2 × 0.2	15.3	15.8	0.4	0.4	20.8	»
61		0 51.2	— 38 26.5	—	0.2 × 0.2	15.9	16.4	0.3	0.4	15.8	»
62		0 51.5	— 38 41.5	—	0.4 × 0.2	15.6	15.7	0.8	1.2	31.0	»
63		0 52.5	— 38 06	—	0.4 × 0.3	15.6	15.5	0.8	0.9	31.7	»
64	Helw 331	0 53.7	— 8 14	—	0.2 × 0.1	15.4	15.1	0.4	0.6	11.7	17.9
65	Helw 332	0 54.0	— 7 38	—	0.4 × 0.3	15.3	15.2	1.0	1.0	27.0	»
66	Helw 333	0 54.0	— 8 13	—	0.3 × 0.2	17.1	16.7	0.5	0.9	24.2	»
67	Helw 334	0 54.2	— 7 55	—	0.4 × 0.4	15.8	15.3	1.3	1.5	24.8	»
68	Helw 335	0 54.5	— 8 20.5	—	0.2 × 0.2	16.4	16.2	0.7	1.0	20.1	»
69	NGC 337	0 54.8	— 8 07.5	S	2.2 × 1.4	12.8	11.9	6.3	7.0	9.0	»
70		0 54.9	— 8 13.5	—	0.2 × 0.1	16.4	16.2	0.2	0.8	15.6	»
71	Helw 336	0 54.9	— 8 20.5	—	0.4 × 0.3	16.4	15.9	1.1	0.5	23.0	»
72	Helw 337	0 55.1	— 8 15.5	—	1.0 × 0.4	13.8	13.6	1.2	1.6	34.4	»
73		0 55.6	— 8 31	—	0.9 × 0.8	15.3	15.1	2.3	2.8	17.2	»
74		0 55.6	— 7 38	—	0.7 × 0.5	15.0	15.4	0.6	1.6	22.5	»
75	Helw 338	0 55.8	— 7 34.5	—	0.7 × 0.5	16.4	15.9	1.5	1.4	20.5	»
76		0 56.4	— 8 05	—	0.2 × 0.1	15.9	15.9	0.7	0.5	23.9	»
77	Helw 341	0 56.5	— 8 07.5	S	2.0 × 2.0	14.5	13.6	4.4	3.0	25.0	»
78		0 57.2	— 7 43.5	—	0.2 × 0.2	15.8	15.9	0.2	0.6	36.7	»
79		0 58.0	— 8 02.5	—	0.7 × 0.5	15.6	15.2	0.5	0.8	45.9	»
80		0 58.0	— 7 31	—	0.9 × 0.4	14.3	13.8	1.7	2.9	53.7	»

No	Catalogue number	Coordinates (1900)		Type	Dimensions	Total magnitude		Resolution class		Distance from centre of plate	Limiting magnitude of plate
		α	δ			Samaha	Svenonius	Svenonius	Lundmark		
		<i>h m</i>				<i>m</i>	<i>m</i>	<i>R</i>	<i>R</i>		<i>m</i>
81		1 24.5	— 23° 15'	—	0'2 × 0'2	—	16.2	0.4	0.4	24'8	18.0
82		1 24.8	— 22 50	—	0.3 × 0.2	15.1	15.5	1.2	0.9	29.4	"
83		1 24.8	— 22 51.5	—	0.8 × 0.3	14.7	14.8	1.7	1.8	27.7	"
84		1 25.3	— 23 18	—	0.6 × 0.2	15.1	15.0	1.5	1.6	12.8	"
85	NGC 578	1 25.6	— 23 12	S	4.7 × 2.5	12.2	12.0	7.5	7.5	7.7	"
86		1 25.9	— 22 54.5	—	0.6 × 0.2	15.6	15.8	0.9	0.7	17.5	"
87		1 26.0	— 23 15	—	0.2 × 0.1	15.8	15.9	0.3	0.8	3.5	"
88		1 26.5	— 22 57.5	—	0.6 × 0.3	15.5	15.4	1.1	2.1	19.0	"
89		1 27.0	— 29 28	—	0.3 × 0.3	15.0	15.8	0.5	0.9	44.0	17.0
90		1 27.2	— 22 58	—	0.3 × 0.2	15.5	15.8	0.8	1.5	22.0	18.0
91	NGC 613	1 29.6	— 29 55	S	5.0 × 2.6	11.5	10.7	7.0	7.8	4.4	17.0
92		2 17.4	— 21 16	—	0.8 × 0.4	13.2	13.2	3.0	3.0	31.6	16.7
93		2 17.5	— 21 11	—	0.3 × 0.2	13.9	14.1	0.4	0.5	34.7	"
94		2 17.6	— 21 44	—	0.3 × 0.2	15.0	14.7	0.4	0.5	14.7	"
95	NGC 907	2 18.4	— 21 10	—	1.3 × 0.3	12.8	12.8	3.7	4.2	32.5	"
96	NGC 908	2 18.5	— 21 41	S	4.6 × 1.5	10.7	10.6	7.1	7.3	1.8	"
97	Helw 372	2 23.4	— 3 36	—	0.5 × 0.4	14.5	14.5	0.8	0.8	29.5	17.3
98		2 24.1	— 3 12.5	—	0.2 × 0.2	15.3	15.4	0.5	0.6	27.7	"
99	Helw 373	2 24.2	— 3 44.5	—	0.4 × 0.3	14.8	14.9	1.2	1.1	32.5	"
100	Helw 374	2 24.5	— 3 39.5	E	0.8 × 0.7	13.8	13.2	1.9	2.2	26.2	"
101		2 24.6	— 3 28.5	—	0.2 × 0.2	15.3	15.9	1.5	1.5	19.4	"
102		2 25.3	— 3 26	—	0.1 × 0.1	15.6	15.9	0.7	1.0	8.5	"
103	Helw 375	2 25.4	— 3 33	—	0.3 × 0.2	15.0	15.0	1.6	2.1	12.4	"
104	Helw 376	2 25.5	— 3 19.5	S	0.7 × 0.6	14.8	14.5	2.8	2.9	6.0	"
105	NGC 958	2 25.7	— 3 23	S	2.3 × 0.7	11.5	11.5	5.5	5.7	2.8	"
106	Helw 377	2 25.7	— 3 20.5	—	0.2 × 0.1	14.8	15.0	1.4	1.2	3.1	"
107	Helw 378	2 25.7	— 3 23.5	—	0.2 × 0.1	14.8	14.9	0.8	0.6	3.0	"
108		2 25.8	— 3 21	—	0.1 × 0.1	15.9	15.9	0.4	0.6	2.1	"
109		2 25.8	— 3 23.5	—	0.2 × 0.2	15.5	15.9	0.6	1.0	1.2	"
110	Helw 379	2 26.1	— 3 23	—	0.3 × 0.1	14.4	14.5	1.7	2.3	4.6	"
111		2 26.4	— 3 19.5	—	0.3 × 0.3	15.3	15.4	0.9	0.6	9.3	"
112	Helw 380	2 26.4	— 3 33.5	—	0.4 × 0.1	14.6	14.9	1.1	1.2	14.0	"
113	Helw 381	2 26.7	— 3 36	—	0.3 × 0.2	14.7	14.9	1.7	1.9	19.4	"
114		2 27.3	— 3 22.5	—	0.8 × 0.3	15.2	14.9	1.4	1.7	21.6	"
115	Helw 382	2 33.1	— 8 30	—	0.4 × 0.3	—	14.8	0.7	0.6	40.8	16.8
116	Helw 383	2 33.2	— 8 48	—	0.4 × 0.2	14.3	14.5	1.0	1.4	35.0	"
117	Helw 384	2 33.6	— 8 32.5	—	0.3 × 0.3	14.6	15.1	0.8	0.7	34.5	"
118	Helw 385	2 33.9	— 8 59	—	0.2 × 0.2	14.6	15.1	1.3	1.1	25.5	"
119	NGC 1035	2 34.6	— 8 34	S	1.9 × 0.5	12.6	12.4	2.4	3.4	21.7	"
120	Helw 386	2 35.4	— 9 12.5	—	0.6 × 0.6	13.9	14.4	1.8	2.7	22.1	"
121	NGC 1042	2 35.5	— 8 52	S	3.1 × 2.9	13.4	13.0	6.0	6.8	1.8	"
122	NGC 1047	2 35.6	— 8 34.5	—	0.7 × 0.3	13.8	14.2	2.0	2.2	15.7	"
123	NGC 1048:1	2 35.7	— 8 59	—	0.8 × 0.3	—	14.8	3.0	4.0	8.5	"
124	NGC 1048:2	2 35.7	— 8 58	—	0.9 × 0.3	—	14.1	2.7	3.3	8.6	"
125	Helw 389	2 35.9	— 8 24.5	—	0.4 × 0.4	14.5	14.5	0.7	1.2	26.5	"
126		2 36.1	— 8 57	—	0.7 × 0.1	14.4	15.0	1.7	1.9	8.0	"
127	NGC 1052	2 36.2	— 8 41.5	E	1.1 × 0.6	12.9	11.7	2.1	3.1	13.0	"
128	Helw 391	2 36.7	— 8 36.5	—	0.3 × 0.2	14.9	15.3	0.9	0.8	21.9	"
129	NGC 1069	2 38.1	— 8 43.5	—	1.0 × 0.5	14.5	13.7	1.6	2.0	38.4	"
130	NGC 1071	2 38.2	— 9 12.5	—	0.3 × 0.3	14.4	14.2	0.5	0.8	45.4	"
131		2 38.5	— 0 33	—	0.5 × 0.4	16.3	15.8	0.6	0.5	47.0	17.5
132		2 38.5	— 0 57.5	—	0.5 × 0.3	14.8	14.8	0.9	1.0	42.0	"
133		2 38.8	— 1 02.5	—	0.4 × 0.3	15.1	15.2	0.8	1.4	39.0	"
134		2 39.1	— 1 03.5	—	0.2 × 0.2	15.1	15.5	0.3	0.4	35.2	"
135		2 39.7	— 0 55.5	—	0.3 × 0.3	15.4	15.8	0.7	0.5	24.5	"
136		2 40.1	— 1 10	—	0.2 × 0.1	15.3	15.4	0.5	0.4	24.9	"
137		2 40.4	— 1 17.5	—	0.2 × 0.2	15.4	16.0	0.3	0.5	26.0	"
138		2 40.6	— 0 58.5	—	0.3 × 0.3	15.8	15.9	0.8	0.7	12.0	"
139		2 40.6	— 0 57.5	S	0.5 × 0.4	14.6	14.9	1.8	1.9	11.2	"
140		2 40.6	— 1 04	—	0.1 × 0.1	16.3	16.1	0.1	0.4	14.9	"
141		2 40.7	— 0 39.5	—	0.3 × 0.2	16.0	16.5	1.1	0.7	18.5	"

No	Catalogue number	Coordinates (1900)		Type	Dimensions	Total magnitude		Resolution class		Distance from centre of plate	Limiting magnitude of plate
		α	δ			Samaha	Svenonius	Svenonius	Lundmark		
		<i>h m</i>				<i>m</i>	<i>m</i>	<i>R</i>	<i>R</i>		<i>m</i>
142		2 40.8	— 0°56'5	—	0'2 × 0'1	15.4	15.8	0.5	0.6	8'8	17.5
143		2 40.8	— 0 41	—	0.2 × 0.1	15.9	16.3	1.0	0.4	16.3	»
144		2 40.8	— 1 10.5	—	0.3 × 0.3	15.6	15.4	0.6	0.4	17.0	»
145		2 40.8	— 0 52	—	0.1 × 0.1	14.8	14.7	0.9	1.3	7.7	»
146		2 40.8	— 1 01	—	0.4 × 0.2	15.2	15.2	1.3	1.6	9.4	»
147		2 40.8	— 30 13	—	0.5 × 0.2	15.1	16.0	1.2	1.7	46.0	17.7
148		2 40.9	— 30 55	—	0.2 × 0.2	15.7	15.9	0.8	1.6	22.7	»
149		2 41.0	— 0 45	—	0.2 × 0.1	15.1	14.9	0.7	0.7	9.3	17.5
150		2 41.0	— 1 01	—	0.1 × 0.1	15.0	16.0	0.5	0.5	7.5	»
151		2 41.2	— 1 01.5	—	0.2 × 0.1	15.1	15.3	0.9	0.8	10.0	»
152	NGC 1087	2 41.3	— 0 55	S	3.0 × 1.5	12.2	11.3	7.8	9.1	0.5	»
153		2 41.4	— 1 04.5	—	0.5 × 0.2	14.8	15.0	1.9	2.2	9.5	»
154		2 41.4	— 0 46	—	0.3 × 0.2	15.2	15.5	1.4	0.8	8.0	»
155	NGC 1090	2 41.5	— 0 40	S	3.0 × 1.4	12.7	12.2	5.3	5.8	15.0	»
156		2 41.5	— 1 04	—	0.1 × 0.1	15.4	14.8	0.4	0.5	9.7	»
157		2 41.5	— 0 52.5	—	0.4 × 0.3	14.7	15.1	2.3	0.7	3.3	»
158		2 41.5	— 1 15.5	—	0.2 × 0.1	15.5	15.6	0.7	1.5	20.5	»
159		2 41.6	— 1 14.5	—	0.2 × 0.2	15.8	16.0	0.5	0.4	19.8	»
160		2 41.7	— 0 51	—	0.2 × 0.2	15.6	16.0	1.0	0.6	6.2	»
161		2 41.7	— 1 08.5	—	0.7 × 0.3	14.8	15.1	2.1	2.0	14.4	»
162		2 41.7	— 0 59	—	0.2 × 0.2	15.1	14.8	1.4	0.8	6.4	»
163		2 41.8	— 1 18.5	—	0.3 × 0.2	15.1	15.5	0.7	1.4	24.3	»
164		2 41.8	— 0 52	—	0.2 × 0.2	16.0	15.6	0.6	1.0	6.8	»
165		2 41.8	— 1 14.5	—	0.2 × 0.1	15.5	16.1	0.9	0.6	20.8	»
166		2 41.8	— 0 58.5	—	0.3 × 0.2	14.8	15.1	1.8	1.7	7.6	»
167		2 41.8	— 0 39.5	—	0.1 × 0.1	15.9	15.9	0.4	0.6	17.0	»
168		2 41.8	— 0 34	—	0.4 × 0.1	15.3	15.8	1.3	1.5	21.8	»
169		2 41.9	— 0 32.5	—	0.5 × 0.5	15.0	15.3	2.3	0.5	23.5	»
170		2 41.9	— 1 00.5	E	0.2 × 0.1	14.6	14.5	1.0	0.6	12.5	»
171		2 41.9	— 0 52	—	0.1 × 0.1	15.0	15.3	0.2	0.7	9.6	»
172		2 41.9	— 0 51.5	—	0.3 × 0.2	14.9	15.5	1.4	1.6	9.8	»
173		2 41.9	— 30 44.5	—	0.2 × 0.1	15.8	16.2	0.5	0.7	4.6	17.7
174		2 41.9	— 30 38	E	0.5 × 0.3	14.2	14.2	2.0	2.2	4.6	»
175		2 42.1	— 1 27.5	—	0.3 × 0.3	15.1	15.2	0.5	0.6	34.0	17.5
176		2 42.1	— 0 48	—	0.1 × 0.1	15.3	15.0	0.4	0.7	13.8	»
177	NGC 1097	2 42.1	— 30 41	S	9.5 × 7.0	11.4	10.8	8.6	9.6	1.5	17.7
178		2 42.2	— 0 52.5	—	0.5 × 0.1	14.9	15.2	1.6	0.6	13.6	17.5
179		2 42.2	— 1 09.5	—	0.2 × 0.2	15.0	15.2	0.7	0.8	19.6	»
180	NGC 1094	2 42.3	— 0 41	—	1.2 × 1.0	13.2	13.0	3.7	2.9	19.5	»
181		2 42.3	— 0 40.5	—	0.5 × 0.2	14.5	14.3	2.2	1.4	20.3	»
182		2 42.9	— 1 09	—	0.2 × 0.2	15.0	15.2	0.7	1.8	27.0	»
183		2 42.9	— 30 29	—	0.2 × 0.2	15.5	15.8	0.4	0.5	18.7	17.7
184		2 43.0	— 1 09.5	—	0.3 × 0.3	14.4	14.6	0.4	0.9	29.0	17.5
185		2 43.5	— 0 57.5	—	0.3 × 0.1	15.5	15.8	0.8	1.0	31.5	»
186		2 43.5	— 1 24	—	0.9 × 0.3	15.1	15.4	1.0	0.7	43.0	»
187	NGC 1104	2 43.5	— 0 42	—	0.8 × 0.3	14.5	14.0	1.7	1.1	35.0	»
188	IC 1856	2 43.7	— 1 09	—	0.9 × 0.3	14.0	14.0	1.4	2.2	38.8	»
189		2 43.8	— 1 22.5	—	0.4 × 0.3	15.1	15.0	0.8	0.4	45.6	»
190		2 43.9	— 1 17	—	0.2 × 0.2	15.6	15.8	0.4	0.3	44.0	»
191		2 44.0	— 1 18.5	—	0.5 × 0.5	15.3	15.0	0.6	0.8	46.0	»
192		2 44.1	— 1 09.5	—	0.3 × 0.3	15.5	15.4	0.4	0.7	44.0	»
193		2 44.4	— 1 16.5	—	0.6 × 0.5	13.8	13.6	1.5	1.2	49.7	»
194		2 44.4	— 31 11	—	0.2 × 0.2	15.2	15.9	0.8	0.8	44.7	17.7
195		2 44.5	— 1 07.5	—	0.5 × 0.3	14.8	14.9	0.9	0.7	48.2	17.5
196		2 44.5	— 0 28.5	—	0.5 × 0.4	16.1	14.4	1.3	0.8	54.0	»
197		2 44.7	— 31 04.5	—	0.2 × 0.2	15.3	15.0	1.0	1.2	41.2	17.7
198		2 45.0	— 30 58.5	E	0.5 × 0.5	14.4	14.3	2.0	2.7	44.6	»
199		2 45.1	— 30 42.5	—	0.3 × 0.2	15.4	15.7	1.0	0.7	43.5	»
200		2 56.0	— 22 41	—	0.8 × 0.4	15.5	15.0	0.9	0.9	42.4	17.5
201		2 56.6	— 23 11	—	0.1 × 0.1	16.3	15.4	0.5	1.3	25.4	»
202		2 57.4	— 23 25.5	—	0.4 × 0.2	16.0	15.9	1.0	0.9	23.0	»

No	Catalogue number	Coordinates (1900)		Type	Dimensions	Total magnitude		Resolution class		Distance from centre of plate	Limiting magnitude of plate.
		α	δ			Samaha	Svenonius	Svenonius	Lundmark		
		h m				m	m	R	R		m
203		2 57.9	— 23°04'	—	0'1 × 0'1	16.3	15.8	1.0	0.7	5'7	17.5
204		2 57.9	— 22 42.5	—	0.5 × 0.3	15.9	15.2	0.8	1.2	24.6	»
205		2 58.0	— 23 11	—	0.5 × 0.3	15.9	15.2	1.9	1.2	5.3	»
206		2 58.1	— 23 31	—	0.2 × 0.1	16.0	14.8	1.0	1.3	24.4	»
207	NGC 1187	2 58.2	— 23 15	S	4.0 × 3.0	12.1	11.3	7.4	7.8	8.5	»
208		2 58.7	— 23 34.5	—	0.8 × 0.7	13.9	14.0	1.9	2.4	29.4	»
209		2 59.0	— 23 31.5	—	0.1 × 0.1	16.3	15.7	0.4	0.5	27.9	»
210		2 59.2	— 22 38	—	0.9 × 0.3	15.1	14.2	2.3	1.7	32.5	»
211	NGC 1232	3 05.3	— 20 58	S	6.7 × 6.2	11.1	10.6	9.2	9.3	1.7	17.4
212		3 05.5	— 20 59.5	M	0.7 × 0.5	14.1	14.8	3.3	3.8	2.8	»
213		3 07.6	— 21 25.5	—	0.4 × 0.2	14.3	14.8	1.5	0.3	43.6	»
214		3 07.6	— 21 24	—	0.8 × 0.8	14.5	14.8	0.5	0.8	44.5	»
215		3 27.2	— 19 37.5	—	0.4 × 0.3	15.4	14.0	0.9	0.8	34.5	16.9
216	NGC 1359	3 29.3	— 19 49.5	M	1.8 × 1.5	13.1	11.7	5.4	5.5	1.7	»
217	Helw 400	3 29.3	— 19 54	—	0.6 × 0.5	15.0	14.4	1.8	2.0	5.7	»
218		3 29.5	— 19 52.5	—	0.6 × 0.3	15.4	15.2	0.7	1.0	5.3	»
219	Helw 403	3 29.7	— 19 53.5	—	0.4 × 0.2	14.7	14.7	1.4	0.7	7.5	»
220	Helw 404	3 29.8	— 19 45.5	S	1.0 × 0.5	14.1	13.7	2.7	2.2	7.5	»
221	NGC 1365	3 29.8	— 36 28	S	5.3 × 3.0	11.6	10.9	5.0	5.0	2.0	16.0
222		3 30.1	— 19 22	—	0.8 × 0.4	14.7	14.2	2.0	1.8	29.4	16.9
223	NGC 1371	3 30.7	— 25 16.5	E	0.8 × 0.8	14.2	13.1	2.0	2.9	41.8	»
224		3 32.4	— 36 19	—	0.8 × 0.4	12.7	12.5	1.3	1.6	38.5	16.0
225	Helw 405	3 32.6	— 25 14.5	—	0.5 × 0.2	15.2	14.4	2.0	2.0	25.5	16.9
226	NGC 1385	3 33.2	— 24 50	S	2.5 × 1.1	12.9	11.5	6.5	7.1	0.6	»
227	Helw 406	3 33.3	— 25 10.5	—	0.4 × 0.3	15.2	15.0	0.8	0.7	20.4	»
228	NGC 2835	9 13.4	— 21 56	S	6.5 × 4.0	11.2	11.2	9.3	9.3	4.6	17.9
229		9 15.0	— 22 22.5	—	0.3 × 0.3	14.8	15.0	1.2	2.3	33.9	»
230		9 15.2	— 22 20.5	—	0.5 × 0.3	14.9	14.8	1.4	2.0	33.6	»
231		9 16.7	— 22 03.5	—	2.0 × 0.8	14.8	14.4	2.0	2.0	46.6	»
232	NGC 2997	9 41.3	— 30 44	S	6.4 × 4.5	11.7	10.7	8.5	8.5	1.0	16.9
233		9 43.1	— 30 29.5	—	0.4 × 0.2	15.0	14.0	1.5	1.7	30.5	»
234		9 50.2	— 32 39	—	0.9 × 0.2	15.5	14.8	1.6	1.7	9.7	17.8
235	IC 2522	9 50.8	— 32 40	S	1.6 × 1.5	13.0	12.2	5.7	5.9	0.5	»
236		9 50.8	— 32 44	S	0.9 × 0.3	14.3	13.1	3.4	3.8	4.9	»
237		9 57.2	— 25 33	—	0.7 × 0.3	14.7	15.2	2.5	1.5	21.0	18.1
238		9 57.8	— 26 46	—	0.3 × 0.3	15.2	15.2	1.5	0.6	11.9	»
239		9 58.0	— 25 35.5	E	0.2 × 0.2	15.4	15.4	0.5	0.8	7.0	»
240	NGC 3109	9 58.5	— 25 41	M	18.0 × 2.0	11.1	11.5	8.5	9.7	1.6	»
241		9 59.2	— 26 08	—	0.5 × 0.5	15.1	15.4	2.2	0.9	27.8	»
242	NGC 3115	10 00.3	— 7 14	E	2.5 × 0.5	10.2	9.4	1.9	1.3	3.9	15.8
243	Helw 432	10 58.0	— 23 03	—	0.7 × 0.3	15.4	14.0	2.4	3.0	30.7	17.7
244	NGC 3511	10 58.5	— 22 33	S	4.6 × 1.2	12.4	11.5	6.4	6.6	1.8	»
245	NGC 3513	10 58.9	— 22 42.5	S	1.9 × 1.6	12.9	12.2	6.8	6.9	9.0	»
246	Helw 433	11 00.0	— 22 36	—	0.4 × 0.4	15.9	14.9	1.7	2.8	19.5	»
247		11 51.5	— 19 00	—	0.7 × 0.4	15.2	14.7	1.5	2.1	49.6	»
248		11 52.3	— 18 32	—	0.3 × 0.3	16.1	14.5	1.2	1.4	5.0	17.3
249	HN 1515	11 52.4	— 0 42.5	—	1.0 × 0.3	14.7	15.1	1.0	1.6	44.5	17.6
250		11 52.7	— 18 49	—	0.5 × 0.3	16.2	15.9	1.3	1.6	28.0	17.7
251		11 53.3	— 18 58	—	0.2 × 0.1	16.1	14.4	0.5	0.5	22.4	17.3
252	HN 1538	11 53.7	— 0 55	—	1.0 × 0.8	14.8	14.9	2.6	2.2	33.3	17.6
253	Helw 147	11 53.9	— 18 28	M	0.6 × 0.2	15.1	13.7	2.9	3.2	15.5	17.3
254		11 53.9	— 0 31.5	—	0.2 × 0.2	15.9	15.9	0.8	0.3	22.6	17.4
255		11 54.1	— 0 02.5	—	0.2 × 0.2	13.6	14.0	1.5	1.0	36.8	»
256		11 54.2	— 0 33	—	0.2 × 0.2	15.3	15.5	0.5	0.5	19.6	»
257	HN 1545	11 54.2	— 0 36.5	—	0.7 × 0.2	15.2	15.1	1.1	0.7	15.2	17.6
258	IC 754	11 54.2	— 1 06	E	0.4 × 0.2	15.4	14.6	0.5	0.5	36.7	»
259	Helw 148	11 54.4	— 18 46.5	—	0.8 × 0.4	14.9	13.8	2.8	2.8	4.6	17.3
260	NGC 4027	11 54.4	— 18 43	S	2.0 × 1.3	12.2	11.0	6.6	6.5	0.7	17.7
261		11 54.5	— 18 46	—	0.1 × 0.1	16.4	16.5	0.5	0.6	3.8	17.3
262		11 54.5	— 18 47	—	0.2 × 0.1	15.8	15.5	1.2	0.4	5.0	»
263	HN 1556	11 54.7	— 0 50	—	0.2 × 0.1	15.7	15.5	0.4	0.5	18.8	17.6

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		α	δ			Samaha	Svenonius	Svenonius	Lundmark		
		<i>h m</i>				<i>m</i>	<i>m</i>	<i>R</i>	<i>R</i>		<i>m</i>
264		11 54.8	— 0°01'	—	0'5 × 0'4	15.1	15.2	1.0	0.6	30'7	17.4
265		11 55.1	— 18 49	—	0.2 × 0.2	15.8	14.5	1.6	1.5	12.6	17.3
266		11 55.2	— 18 49	M	0.5 × 0.3	15.5	14.0	3.0	3.0	13.3	»
267	NGC 4030	11 55.3	— 0 32	S	3.8 × 2.6	12.1	11.0	8.5	8.1	0.8	17.6
268		11 55.3	— 0 33.5	—	0.1 × 0.1	15.8	16.0	0.1	0.5	23.4	»
269	HN 1566	11 56.0	— 0 45	M	1.0 × 0.9	14.4	14.2	3.7	4.4	16.4	»
270		11 56.0	— 18 32	—	1.0 × 0.3	16.1	15.8	0.9	0.4	26.9	17.3
271		11 56.2	— 18 34.5	—	0.3 × 0.3	15.8	15.1	0.9	1.1	27.3	»
272	HN 1569	11 56.3	— 0 10	—	0.5 × 0.5	14.8	14.9	1.1	1.7	28.0	17.6
273	HN 1571	11 56.8	— 0 31.5	—	0.8 × 0.2	14.8	15.1	1.6	1.8	22.7	»
274	NGC 4038	11 56.8	— 18 19	S	2.5 × 2.2	12.3	10.6	5.6	6.3	41.0	17.3
275	NGC 4208	12 10.5	+ 14 28	S	1.8 × 0.9	12.2	12.3	2.2	2.8	57.7	16.5
276		12 11.6	+ 14 51	—	0.3 × 0.3	14.0	14.0	0.4	0.8	34.0	»
277	NGC 4254	12 13.7	+ 14 59	S	5.0 × 4.0	10.7	10.3	8.3	8.6	1.7	»
278		12 13.9	+ 5 20	—	0.7 × 0.3	14.3	13.9	2.7	2.0	49.9	17.2
279	Lick 394	12 14.1	+ 15 06	—	0.1 × 0.1	14.7	14.8	0.2	0.5	8.7	16.5
280	NGC 4262	12 14.4	+ 15 27	E	0.3 × 0.2	13.5	13.3	0.2	0.6	29.8	»
281		12 14.8	+ 14 26	—	0.2 × 0.2	14.2	14.2	0.2	0.6	35.6	»
282	Lick 403	12 15.2	+ 4 46	S	1.6 × 0.2	14.3	14.4	1.6	2.5	30.4	17.2
283	Lick 408	12 16.2	+ 5 08	—	1.0 × 0.6	14.0	14.2	2.8	2.8	13.5	»
284		12 16.2	+ 5 11	—	0.3 × 0.2	16.0	15.3	0.8	0.5	14.7	»
285	NGC 4298	12 16.4	+ 15 10	S	2.0 × 1.0	12.3	12.4	3.5	3.2	40.4	16.5
286		12 16.4	+ 5 20	—	0.8 × 0.2	14.6	14.4	2.0	2.2	20.0	17.2
287	NGC 4303	12 16.8	+ 5 01.5	S	5.0 × 4.2	11.6	10.7	8.3	8.5	1.4	»
288		12 17.2	+ 5 13	E	0.2 × 0.2	14.7	13.5	0.1	1.5	12.5	»
289	Lick 420	12 17.3	+ 5 07	S	0.9 × 0.9	13.4	13.8	4.0	4.0	9.4	»
290		12 18.7	+ 4 39	—	0.5 × 0.4	14.5	15.4	0.9	1.3	36.0	»
291		12 23.9	— 7 45.5	—	0.5 × 0.3	15.9	14.9	1.2	1.5	47.5	17.6
292		12 24.4	— 7 55	—	0.8 × 0.4	14.1	14.1	2.1	2.4	34.2	»
293		12 24.5	— 7 38	—	0.3 × 0.3	15.9	15.8	0.9	0.6	24.0	»
294		12 25.0	— 7 53	—	1.5 × 1.0	14.7	13.9	4.6	3.7	26.0	»
295		12 25.5	— 7 24.5	—	0.4 × 0.3	16.4	15.2	1.0	0.8	16.5	»
296		12 25.5	— 7 01.5	—	0.6 × 0.2	15.6	15.1	1.4	1.4	14.6	»
297	NGC 4487	12 25.8	— 7 32	S	4.0 × 2.5	12.6	11.6	6.3	7.0	20.7	»
298		12 26.6	— 7 20.5	—	0.4 × 0.3	16.1	14.9	1.2	1.0	10.2	»
299		12 26.8	— 7 16	—	0.4 × 0.4	16.1	15.0	0.9	1.1	10.4	»
300		12 26.9	— 7 36	—	0.3 × 0.2	15.7	15.9	1.3	0.6	13.8	»
301	NGC 4504	12 27.1	— 7 00	S	3.5 × 2.0	12.6	11.8	5.2	5.5	15.8	»
302		12 27.1	— 6 54	—	0.3 × 0.2	16.1	15.5	0.9	0.7	23.6	»
303		12 27.2	— 7 58	—	0.4 × 0.2	15.6	15.7	1.4	1.5	32.7	»
304		12 27.3	— 7 20	E	0.7 × 0.4	14.9	14.9	1.0	1.8	43.6	»
305		12 27.8	— 6 53	—	0.6 × 0.4	16.0	15.1	1.6	2.0	31.0	»
306		12 27.9	— 6 47	—	0.7 × 0.5	16.1	14.8	0.7	1.0	36.6	»
307		12 28.6	— 6 48.5	—	0.3 × 0.2	15.9	14.9	0.5	1.0	22.8	17.8
308		12 32.3	— 4 51.5	—	0.2 × 0.2	16.7	15.2	1.0	0.8	46.5	17.9
309	Helw 153	12 33.5	— 4 23	—	1.0 × 0.3	15.3	14.8	1.4	1.5	32.0	»
310		12 33.7	— 4 30.5	—	0.4 × 0.2	15.6	15.1	0.8	0.5	26.0	»
311	Helw 154	12 33.7	— 5 09	—	0.4 × 0.3	15.9	15.1	0.7	1.4	37.5	»
312		12 34.0	— 4 32	—	0.3 × 0.2	15.6	15.2	1.5	2.0	21.2	»
313	Helw 155	12 34.0	— 4 16.5	—	0.3 × 0.2	15.7	15.0	1.7	1.6	26.0	»
314	Helw 157	12 34.4	— 4 45.5	—	0.2 × 0.2	15.8	15.4	0.3	1.1	14.1	»
315	NGC 4593	12 34.5	— 4 48	S	3.5 × 2.0	12.8	11.5	4.8	4.8	13.8	»
316	Helw 158	12 34.7	— 4 48	—	0.4 × 0.3	14.5	14.6	2.6	2.9	11.7	»
317	NGC 4594	12 34.8	— 11 04.5	E	5.0 × 1.0	10.9	8.3	2.7	2.2	2.6	15.2
318	NGC 4597	12 35.0	— 5 15	S	2.5 × 1.2	12.0	12.0	4.8	4.1	5.7	17.8
319	Helw 159	12 35.1	— 4 50.5	—	0.2 × 0.2	14.4	15.2	0.9	0.7	11.3	17.9
320	Helw 160	12 35.1	— 4 48.5	—	0.3 × 0.3	15.3	14.9	1.1	1.0	9.4	»
321	Helw 161	12 35.1	— 4 47	—	0.3 × 0.2	15.8	15.4	0.7	0.5	7.6	»
322		12 35.3	— 4 25	—	1.0 × 0.3	15.0	14.4	2.3	2.5	15.0	»
323	NGC 4602	12 35.5	— 4 35	S	2.8 × 0.7	11.9	11.7	6.3	6.2	5.7	»
324		12 35.6	— 4 32.5	—	0.3 × 0.2	15.9	15.4	1.0	1.2	8.5	»

No	Catalogue number	Coordinates (1900)		Type	Dimensions	Total magnitude		Resolution class		Distance from centre of plate	Limiting magnitude of plate
		α	δ			Samaha	Svenonius	Svenonius	Lundmark		
		<i>h m</i>				<i>m</i>	<i>m</i>	<i>R</i>	<i>R</i>		<i>m</i>
325	Helw 162	12 35.6	— 4° 45'	—	0'8 × 0'3	14.5	13.7	2.7	3.3	7.4	17.9
326		12 35.7	— 4 51	—	0.4 × 0.2	16.0	16.4	0.7	1.5	24.2	»
327	Helw 163	12 35.9	— 4 40.5	—	0.2 × 0.2	15.7	15.5	1.2	1.2	9.6	»
328		12 36.1	— 4 27.5	E	0.6 × 0.3	14.6	13.8	2.2	2.6	17.6	»
329		12 37.0	— 4 35	—	0.3 × 0.2	15.9	15.4	0.8	0.7	25.8	»
330	Helw 166	12 37.1	— 5 14.5	—	0.3 × 0.3	14.8	14.7	1.1	0.9	25.3	17.8
331		12 37.1	— 5 14.5	—	0.2 × 0.2	15.5	15.4	1.0	2.3	25.7	»
332	Helw 167	12 37.2	— 5 13.5	—	0.5 × 0.3	15.2	14.5	1.2	1.2	25.9	»
333		12 44.2	— 5 54	—	0.4 × 0.2	15.2	15.3	1.1	1.2	24.0	17.3
334		12 44.7	— 6 09	—	0.9 × 0.3	13.5	14.0	3.0	3.1	25.8	»
335	Helw 445	12 45.3	— 10 18.5	S	1.7 × 0.7	14.2	14.3	3.5	1.6	47.0	17.6
336	NGC 4731	12 45.8	— 5 50.5	S	6.0 × 0.8	11.9	11.6	5.1	7.5	0.1	17.3
337	Helw 446	12 46.0	— 6 01	M	0.8 × 0.5	13.8	14.0	3.6	3.6	10.8	»
338	Helw 168	12 46.1	— 10 11.5	—	0.9 × 0.3	15.2	15.5	0.9	1.1	32.4	17.6
339	Helw 448	12 46.3	— 9 41.5	—	0.6 × 0.4	15.2	15.9	0.5	0.9	30.5	»
340	NGC 4742	12 46.6	— 9 54.5	E	1.0 × 0.3	12.7	12.0	1.6	1.0	22.7	»
341	Helw 449	12 46.6	— 6 03	—	0.4 × 0.3	15.0	15.4	0.9	1.0	17.0	17.3
342	Helw 450	12 46.7	— 6 08	—	0.4 × 0.3	14.8	15.4	0.6	1.4	22.5	»
343	NGC 4757	12 47.7	— 9 46	—	1.1 × 0.2	14.2	14.8	2.5	1.0	13.4	17.6
344	Helw 452	12 47.8	— 9 54.5	—	0.1 × 0.1	15.8	16.0	0.3	0.9	7.8	»
345	Helw 453	12 47.8	— 9 45.5	—	0.4 × 0.3	15.4	15.9	0.9	0.7	12.8	»
346	Helw 454	12 47.9	— 9 49.5	—	0.1 × 0.1	14.7	15.8	0.2	0.6	8.8	»
347	Helw 170	12 47.9	— 9 35.5	—	0.5 × 0.3	15.1	15.6	1.2	0.8	21.9	»
348	NGC 4760	12 47.9	— 9 57	E	0.6 × 0.6	14.4	12.6	1.8	1.2	3.0	»
349	NGC 4766	12 47.9	— 9 50	—	0.7 × 0.1	14.5	14.9	1.8	1.2	7.8	»
350	Helw 458	12 48.3	— 9 54	—	0.4 × 0.1	15.2	16.3	1.0	0.7	4.0	»
351	Helw 459	12 48.4	— 9 45.5	E	0.1 × 0.1	14.9	15.9	0.1	0.4	12.3	»
352	NGC 4775	12 48.5	— 6 04	—	1.7 × 1.6	12.5	11.9	4.0	3.8	43.5	17.3
353		12 48.5	— 10 03	—	0.2 × 0.2	15.7	16.0	0.2	0.4	8.1	17.6
354		12 49.0	— 9 53	—	0.3 × 0.3	16.0	16.4	0.3	0.7	14.3	»
355	NGC 4781	12 49.2	— 9 59.5	S	3.1 × 1.0	12.7	11.6	5.9	7.3	15.6	»
356	Helw 461	12 49.2	— 9 40	—	0.8 × 0.2	15.0	16.0	1.1	0.9	23.0	»
357	Helw 462	12 49.3	— 9 37	—	0.5 × 0.2	15.1	16.3	1.0	0.9	26.4	»
358	NGC 4784	12 49.4	— 10 04	E	1.6 × 0.2	14.2	14.6	1.8	0.9	20.0	»
359	NGC 4790	12 49.7	— 9 42	—	1.6 × 0.8	13.5	12.8	4.5	4.5	27.0	»
360	Helw 463	12 49.7	— 9 32	—	0.2 × 0.2	15.3	15.4	1.4	0.6	34.6	»
361	Helw 464	12 49.8	— 10 02	—	0.3 × 0.2	15.7	16.7	0.3	0.6	25.4	»
362		12 59.0	— 27 51.5	—	0.7 × 0.3	16.0	15.8	1.0	0.3	37.5	17.5
363	Helw 301	12 59.7	— 27 51.5	—	1.1 × 0.4	15.2	14.7	1.3	1.8	25.6	»
364	Helw 302	13 00.2	— 27 55	—	1.2 × 0.8	15.0	14.4	2.1	2.0	22.3	»
365	Helw 303	13 00.4	— 27 53	M	2.0 × 0.5	15.5	13.6	3.6	4.0	20.3	»
366	Helw 304	13 01.5	— 28 01	S	3.0 × 2.0	14.2	13.3	5.1	4.4	19.5	»
367		13 01.6	— 14 58	—	1.0 × 0.5	15.4	14.4	2.0	1.9	32.8	18.0
368	NGC 4965	13 01.8	— 27 41	S	3.0 × 2.0	14.1	12.8	4.7	4.0	1.8	17.5
369		13 02.1	— 14 58	—	0.5 × 0.2	16.0	15.4	1.6	1.8	25.5	18.0
370		13 02.8	— 15 15.5	—	0.2 × 0.2	16.5	15.9	0.7	0.7	23.5	»
371		13 02.9	— 15 28.5	E	0.8 × 0.3	15.7	14.4	1.9	1.6	33.0	»
372		13 02.9	— 14 56.5	—	0.3 × 0.1	16.8	16.5	1.0	0.9	13.2	»
373		13 03.0	— 14 45.5	—	0.2 × 0.2	16.1	15.9	1.3	1.0	17.7	»
374		13 03.3	— 14 40	—	0.4 × 0.1	16.4	16.3	0.7	0.8	19.8	»
375		13 03.4	— 14 50	—	0.3 × 0.2	16.2	15.6	1.1	1.2	10.0	»
376		13 03.5	— 14 43	—	0.2 × 0.2	16.7	16.4	0.6	0.7	16.8	»
377	NGC 4980	13 03.7	— 28 07	—	1.0 × 0.7	14.4	14.0	1.8	1.9	35.0	17.5
378	NGC 4984	13 03.7	— 14 59	E	4.0 × 0.8	13.9	12.2	2.5	2.3	1.7	18.0
379		13 03.8	— 15 13.5	—	0.5 × 0.1	16.2	16.3	0.8	0.6	15.4	»
380		13 03.9	— 15 11	—	0.2 × 0.2	16.7	15.4	0.3	0.4	12.5	»
381		13 04.0	— 15 13	—	0.4 × 0.3	16.3	16.1	0.9	0.8	14.5	»
382		13 04.0	— 14 54.5	—	1.2 × 0.3	15.2	14.4	2.0	2.0	4.9	»
383		13 04.1	— 14 48.5	—	0.6 × 0.2	15.9	15.5	1.5	1.1	10.7	»
384		13 04.2	— 15 01.5	—	0.4 × 0.3	16.3	16.1	0.9	1.1	6.1	»
385		13 04.2	— 15 01	—	0.2 × 0.1	16.7	16.1	0.8	0.8	7.1	»

No	Catalogue number	Coordinates (1900)		Type	Dimensions	Total magnitude		Resolution class		Distance from centre of plate	Limiting magnitude of plate
		α	δ			Samaha	Svenonius	Svenonius	Lundmark		
		$h\ m$				m	m	R	R		m
386		13 04.3	— 14° 52' 5	—	0'2 × 0'1	16.8	16.2	0.8	1.1	10'0	18.0
387		13 04.4	— 15 18	—	1.0 × 0.3	15.4	14.9	1.8	1.8	21.8	"
388		13 04.5	— 14 46.5	—	0.2 × 0.2	16.8	16.3	1.5	0.9	15.5	"
389		13 04.7	— 15 13.5	—	2.0 × 0.8	14.9	13.8	3.1	3.1	20.8	"
390		13 05.0	— 14 36.5	E	0.8 × 0.4	15.5	14.2	1.9	1.8	28.0	"
391		13 05.1	— 14 32.5	—	0.5 × 0.4	16.0	15.0	1.7	1.7	32.6	"
392		13 05.1	— 15 01.5	—	0.6 × 0.2	16.4	15.1	2.4	2.8	20.9	"
393		13 05.6	— 15 08.5	—	0.4 × 0.2	16.2	15.7	1.1	1.4	30.0	"
394		13 06.3	— 14 50	—	0.8 × 0.4	15.1	14.4	1.1	1.8	38.5	"
395		13 06.5	— 14 55	E	0.5 × 0.4	15.4	14.3	1.1	1.3	39.9	"
396		13 10.6	— 20 08	—	0.6 × 0.5	16.0	15.5	0.5	0.4	47.9	17.5
397		13 10.9	— 20 10	—	0.6 × 0.4	15.5	15.4	0.6	0.6	42.4	"
398		13 11.4	— 20 26.5	—	0.2 × 0.2	16.0	16.0	0.3	0.5	31.5	"
399		13 12.5	— 20 39	—	0.2 × 0.1	16.1	16.3	0.2	0.4	17.0	"
400		13 12.5	— 23 47	—	0.3 × 0.2	16.0	15.0	0.7	0.5	35.8	"
401		13 13.1	— 20 46.5	—	1.0 × 0.3	15.3	14.8	2.0	2.3	17.7	"
402		13 13.3	— 20 27	—	0.4 × 0.2	15.5	15.5	1.0	0.7	3.8	"
403	NGC 5068	13 13.4	— 20 31	S	7.2 × 6.7	12.0	10.9	7.9	9.4	1.7	"
404	Helw 468	13 13.5	— 24 10.5	—	0.9 × 0.4	15.8	14.9	1.5	0.6	24.6	17.7
405	Helw 469	13 13.7	— 23 53.5	—	1.0 × 0.2	15.6	15.3	1.7	1.1	16.7	"
406	Helw 470	13 14.1	— 23 57.5	—	0.2 × 0.2	16.2	14.8	1.1	0.7	10.6	"
407	Helw 471	13 14.1	— 23 58	—	0.2 × 0.1	15.9	15.4	1.3	1.0	10.8	"
408	NGC 5085	13 14.8	— 23 55	S	2.7 × 2.2	13.0	12.0	5.4	6.8	0.4	"
409		13 14.8	— 23 32.5	—	0.6 × 0.2	15.7	15.5	1.0	0.8	22.6	"
410		13 15.0	— 20 59	—	0.7 × 0.4	—	15.5	1.0	1.4	35.6	"
411		13 15.0	— 20 59	—	0.2 × 0.2	15.9	15.3	0.5	0.5	25.8	"
412	NGC 5087	13 15.0	— 20 04.5	E	1.4 × 0.7	14.4	12.4	1.7	2.0	31.5	17.5
413		13 29.8	— 29 35.5	—	0.2 × 0.2	16.1	15.4	1.2	1.4	29.5	18.7
414	NGC 5236	13 31.4	— 29 21	S	11.0 × 9.0	9.7	10.3	9.8	10.0	1.8	"
415		13 31.8	— 29 19.5	—	0.2 × 0.1	16.2	17.0	0.9	0.8	5.8	"
416		13 31.9	— 29 20	—	0.2 × 0.2	15.9	16.5	1.2	1.5	6.6	"
417	NGC 5247	13 32.7	— 17 22	S	5.0 × 3.5	12.0	11.2	7.4	7.7	1.4	17.1
418		13 33.0	— 29 08.5	—	0.3 × 0.2	16.3	16.1	1.0	1.0	25.6	18.7
419	Helw 473	13 59.5	— 5 05	—	0.3 × 0.2	16.3	14.9	0.4	0.5	29.2	18.1
420	Helw 474	14 01.0	— 5 03	—	0.4 × 0.3	16.3	16.2	0.6	0.9	6.9	"
421	Helw 475	14 01.1	— 5 14.5	—	1.0 × 0.3	15.8	14.7	1.8	3.2	16.5	"
422		14 01.2	— 5 15	—	0.3 × 0.2	16.3	16.4	0.7	1.1	16.2	"
423	NGC 5468	14 01.4	— 4 58.5	S	2.5 × 2.2	13.6	12.4	6.3	7.8	1.5	"
424	NGC 5472	14 01.7	— 4 59	—	0.7 × 0.2	15.7	14.7	1.9	2.0	3.6	"
425		14 02.1	— 4 39.5	—	0.6 × 0.6	16.5	15.9	0.9	0.3	22.0	"
426		14 04.5	— 5 03.5	—	0.6 × 0.4	15.9	15.7	0.4	0.6	45.0	"
427		14 04.8	— 0 46	—	0.4 × 0.4	14.4	14.9	0.5	0.8	29.5	17.3
428		14 05.8	— 30 02.5	—	0.3 × 0.3	14.9	15.1	1.9	1.0	15.5	16.9
429	NGC 5496	14 06.5	— 0 41	M	3.5 × 0.6	12.6	12.5	4.3	3.4	3.8	17.3
430	NGC 5494	14 06.6	— 30 10	S	1.5 × 1.5	14.0	12.9	5.7	6.0	1.9	16.9
431		14 06.6	— 29 45.5	—	0.8 × 0.4	14.4	14.4	2.5	1.4	24.5	"
432		14 07.1	— 0 08.5	—	0.4 × 0.2	14.6	15.4	0.6	0.7	30.5	17.3
433		14 07.5	— 30 00.5	—	0.5 × 0.4	14.7	15.1	1.3	1.2	15.7	16.9
434		14 09.0	— 0 24	—	0.5 × 0.3	14.6	15.1	1.3	0.6	36.0	17.3
435	IC 1091	15 02.8	— 10 45	—	0.4 × 0.2	15.3	14.6	1.4	1.7	19.6	17.1
436	NGC 5858	15 03.4	— 10 49	E	0.2 × 0.1	15.4	12.9	1.2	0.7	10.1	"
437	NGC 5861	15 03.8	— 10 56	S	2.7 × 1.1	13.4	12.5	5.7	4.8	0.9	"
438		15 04.2	— 11 12	—	0.7 × 0.3	15.9	15.4	1.0	0.8	16.2	"
439	NGC 5872	15 05.5	— 11 06	—	0.2 × 0.2	15.6	15.1	1.3	0.8	25.3	"
440		15 05.8	— 10 53	—	1.0 × 0.3	15.2	14.1	1.2	1.4	29.8	"
441	NGC 5885	15 09.7	— 9 42	S	3.0 × 2.3	13.1	12.9	6.0	7.2	1.8	18.7
442	Helw 248	22 26.9	— 26 11	—	0.5 × 0.5	15.3	15.3	1.2	1.5	50.0	17.9
443		22 27.7	— 26 24	—	0.4 × 0.4	15.2	15.9	0.6	1.0	39.0	"
444	Helw 249	22 27.9	— 26 45.5	—	0.4 × 0.3	15.4	15.7	0.8	1.1	32.9	"
445	Helw 250	22 28.4	— 26 56.5	—	0.3 × 0.2	16.0	16.5	0.8	1.3	34.0	"
446		22 28.9	— 26 56.5	—	0.3 × 0.2	15.8	16.2	0.5	1.1	30.0	"

No	Catalogue number	Coordinates (1900)		Type	Dimen- sions	Total magnitude		Resolution class		Distance from centre of plate	Limiting magnitude of plate
		α	δ			Samaha	Svenonius	Svenonius	Lundmark		
		<i>h m</i>				<i>m</i>	<i>m</i>	<i>R</i>	<i>R</i>		<i>m</i>
447	Helw 251	22 29.3	— 26° 11' 5	—	0'2 × 0'2	15.0	15.3	1.3	1.2	25'6	17.9
448	Helw 252	22 29.3	— 26 13.5	—	0.2 × 0.2	16.0	16.1	0.7	0.6	23.6	"
449	NGC 7313	22 30.0	— 26 37	—	0.3 × 0.2	—	15.3	1.0	1.0	4.5	"
450	NGC 7314	22 30.2	— 26 34	S	3.0 × 1.1	12.2	12.0	5.8	7.4	0.2	"
451	Helw 253	22 30.6	— 26 50	—	0.5 × 0.2	14.6	15.2	1.3	2.0	16.5	"
452	Helw 254	22 30.7	— 26 48.5	—	0.2 × 0.1	16.0	16.7	0.9	0.3	15.8	"
453	Helw 255	22 31.1	— 26 46.5	—	0.5 × 0.1	15.1	15.8	1.0	1.3	16.5	"
454	Helw 256	22 33.2	— 26 22.5	—	0.4 × 0.3	15.2	15.1	0.6	1.4	40.7	"
455		22 50.3	— 41 12	—	0.6 × 0.4	14.7	15.2	0.9	1.3	34.7	17.7
456	NGC 7424	22 51.6	— 41 36	S	4.0 × 4.0	12.7	12.2	6.5	7.8	3.6	"
457		22 53.7	— 41 18	—	1.0 × 1.0	14.3	14.1	0.9	1.5	37.6	"
458	IC 5332	23 29.0	— 36 39	S	6.7 × 2.8	14.2	13.0	5.5	5.8	2.8	17.7
459	NGC 7793	23 52.7	— 33 09	S	6.0 × 5.0	10.8	10.4	9.7	10.0	1.0	17.4
460	Helw 505	23 52.8	— 33 26	—	0.6 × 0.4	14.1	14.5	1.0	1.7	18.5	"
461		23 53.2	— 33 30	—	0.3 × 0.2	15.5	15.3	0.7	0.7	23.7	"

PLATES 1—16.

No. 1—2.

The anagalactic objects on Plates 1 and 2 are given to represent various steps of photographic resolution. For approximately each half of the scale, running from 10^R0 to 0^R0 in order, an object is to be found. Below each picture is given its number in the NGC- or the IC-catalogues, or, if it is not contained in any one of these catalogues, its position, referred to the equinox 1900.0. The objects photographed by the author are designated by B. S-s and those by other Helwan-observers by HELW. The objects are given with increasing declination up and increasing right ascension to the left.

On the picture of NGC 3115 it is remarkable to see suspected supernova, situated $1'.0$ north and 2^S4 following (corresponding here to 5.0 mm up and 3.0 mm to the right) from the centre of the object. It was discovered on a visit to Lund by Dr. A. H. SAMAHA September 23rd 1937 on this plate of mine exposed at L.S.T. 10^h15^m — 10^h40^m April 3rd 1935.

No. 3—7.

The microphotographs of anagalactic objects on Plates 3—7, which are to illustrate Chapter IX, are given to show the different appearance for different enlargements. The individual grains (or the groups of grains) are visible already at enlargements of about 20 times. The times of linear magnification are given below each picture, and for the greater magnifications only the centra of the objects enter the pictures.

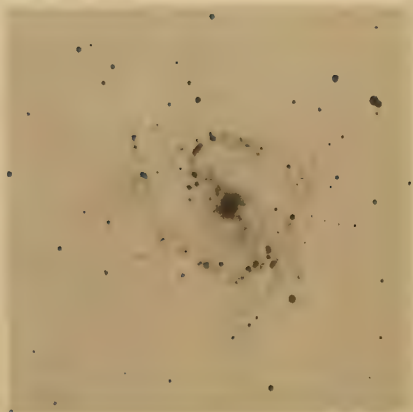
Plate 7 shows a number of black, disturbing lines, which do not belong to the object, but are plate defects. In the gelatine of the original plate at these places cracks are to be found.

No. 8—16.

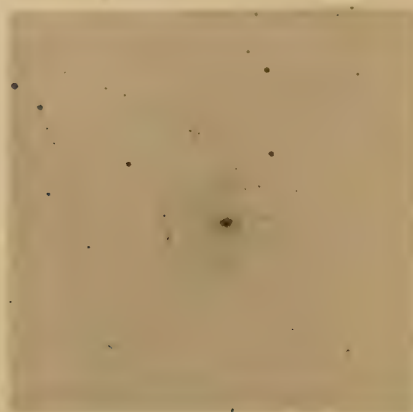
The plates 8—16 are to illustrate the different methods of determining isophotal lines of anagalactic objects, which are discussed in Chapter IX.

The curves are obtained either by measurements in a Schilt photometer or by counts of grains, according to the explanatory text above each picture. Measurements according to both methods which are to be had on same object, are placed besides each other, in order to facilitate comparisons. For NGC 1365 the linear scales are the same, but the dimensions of the squares in the counts of grains are less than the squares of the instrumental photometry. The latter fact is also prevailing for the other pictures with counts of grains. The more, the linear scales are not the same here: the ratio is 1.5 for NGC 4731 and 2.0 for NGC 5496. The objects are so orientated that positive declination is up when the figures are read in a right position.

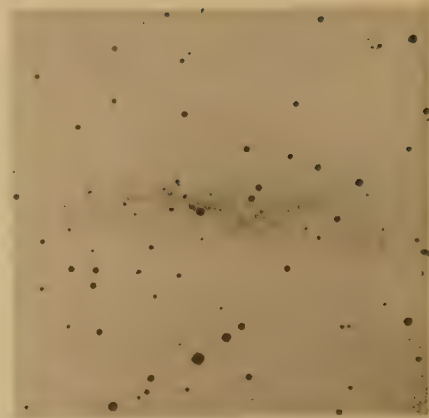
Resolution of anagalactic objects: Plate 1.



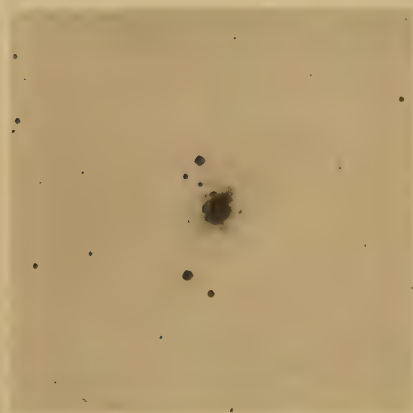
NGC 5236. $R = 9,9$.
Helw. photo.



NGC 1232. $R = 9,3$.
Helw. photo.



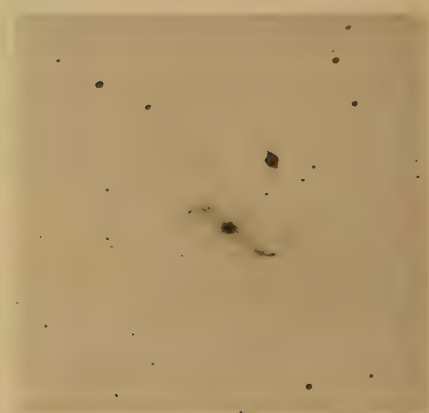
NGC 3109. $R = 8,8$.
B. S-s photo.



NGC 4030. $R = 8,3$.
B. S-s photo.



NGC 1187. $R = 7,8$.
Helw. photo.



NGC 613. $R = 7,4$.
Helw. photo.



NGC 3511. $R = 6,5$.
NGC 3513. $R = 6,9$.
B. S-s photo.



NGC 4602. $R = 6,3$.
B. S-s photo.



NGC 4038. $R = 5,8$.
B. S-s photo.

Resolution of anagalactic objects: Plate 2.



NGC 4504. $R = 5.3$.
Helw. photo.



NGC 4597. $R = 4.5$.
B. S-s photo.



$(12^h17^m2; +5^\circ 13')$. $R = 0.5$.
 $(12^h17^m3; +5^\circ 08')$. $R = 4.0$.
Helw. photo.



IC 2522. $R = 5.8$.
 $(9^h51^m2; -32^\circ 36')$. $R = 3.6$.
Helw. photo.



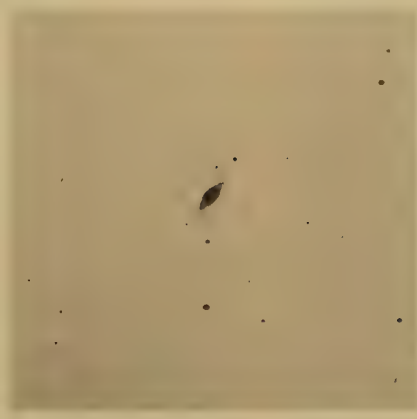
Helw. 162. $R = 3.0$.
B. S-s photo.



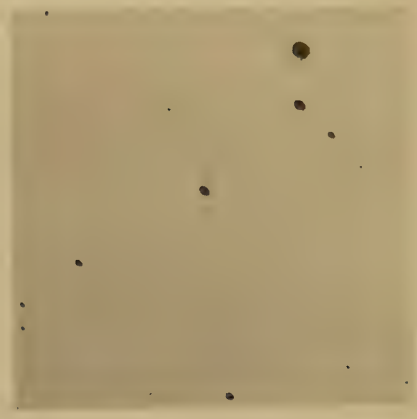
NGC 4594. $R = 2.5$.
B. S-s photo.



NGC 4984. $R = 2.3$.
 $(13^h04^m0; -14^\circ 54')$. $R = 2.0$.
Helw. photo.



NGC 3115. $R = 1.6$.
B. S-s photo.

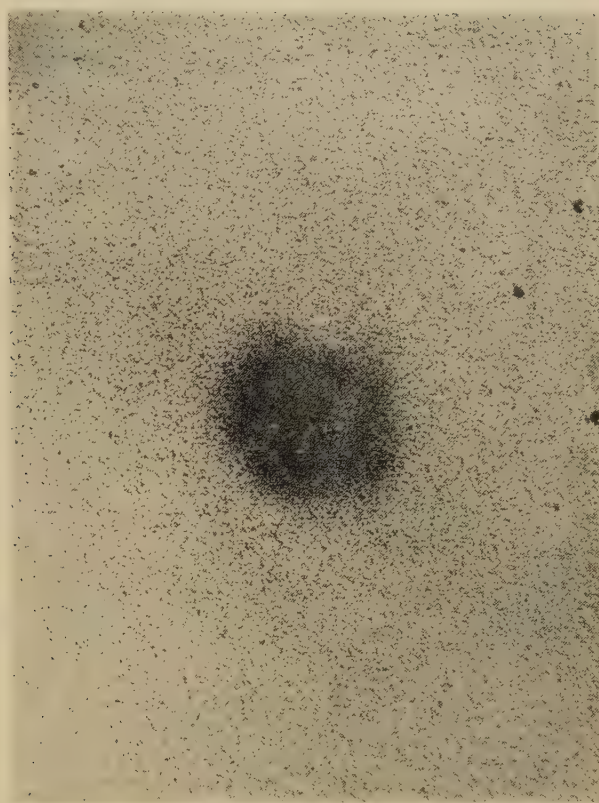


$(0^h42^m6; -31^\circ 58')$. $R = 1.0$.
B. S-s photo.

NGC 1097 in some different enlargements: Plate 3.



20×



50×

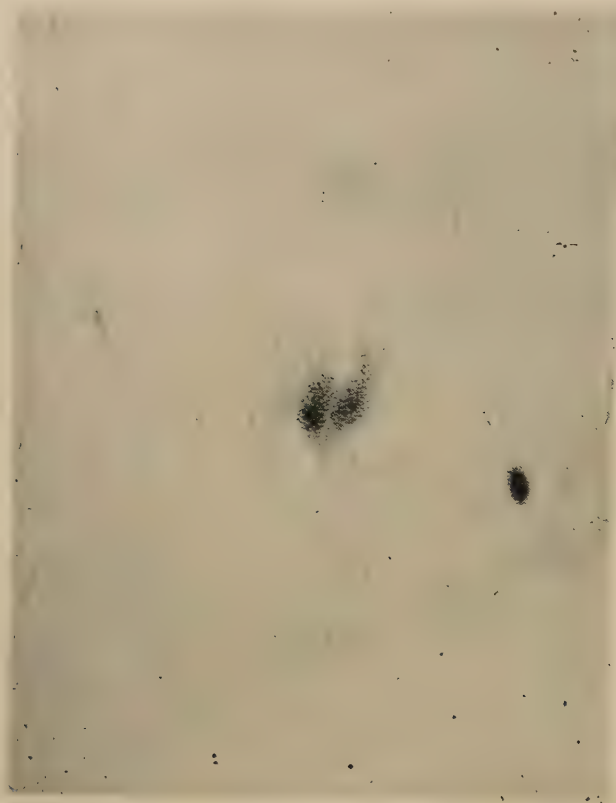


100×



150×

NGC 1365 in some different enlargements: Plate 4.



20 ×



50 ×

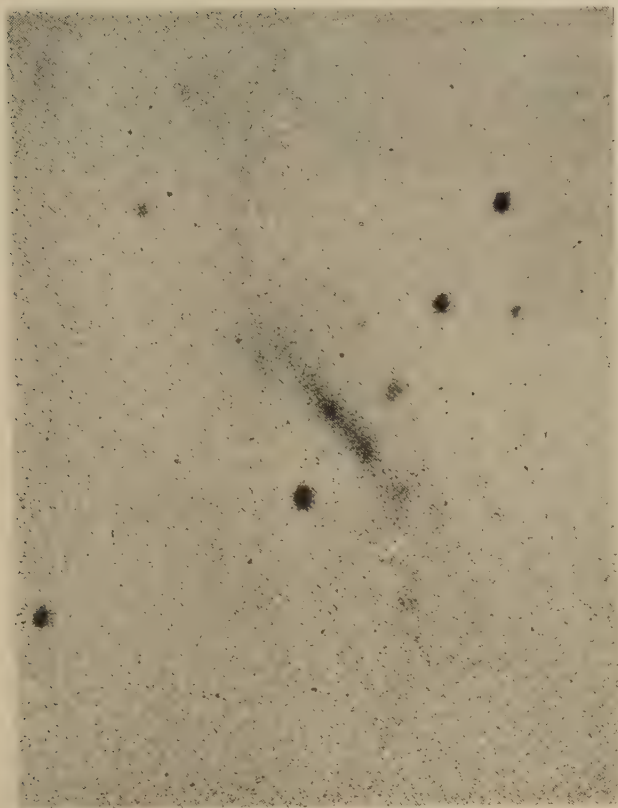


100 ×

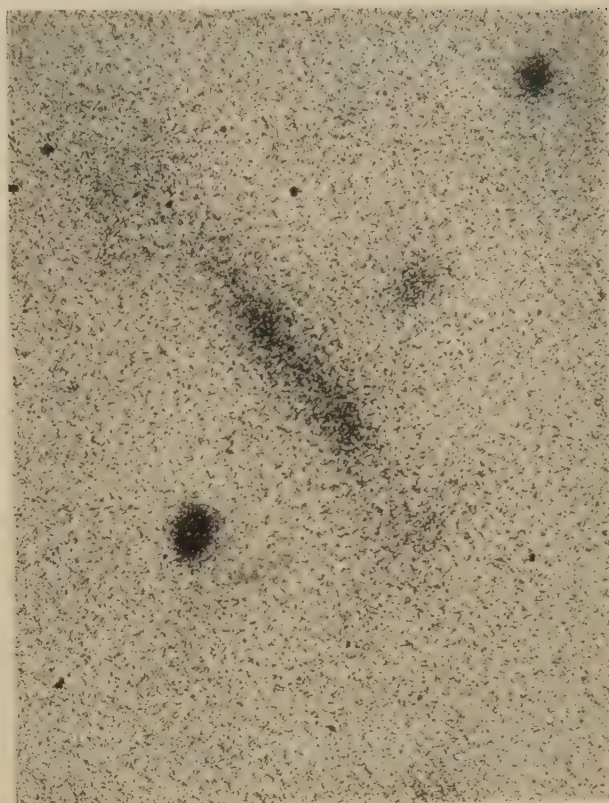


150 ×

NGC 4731 in some different enlargements: Plate 5.



20



50

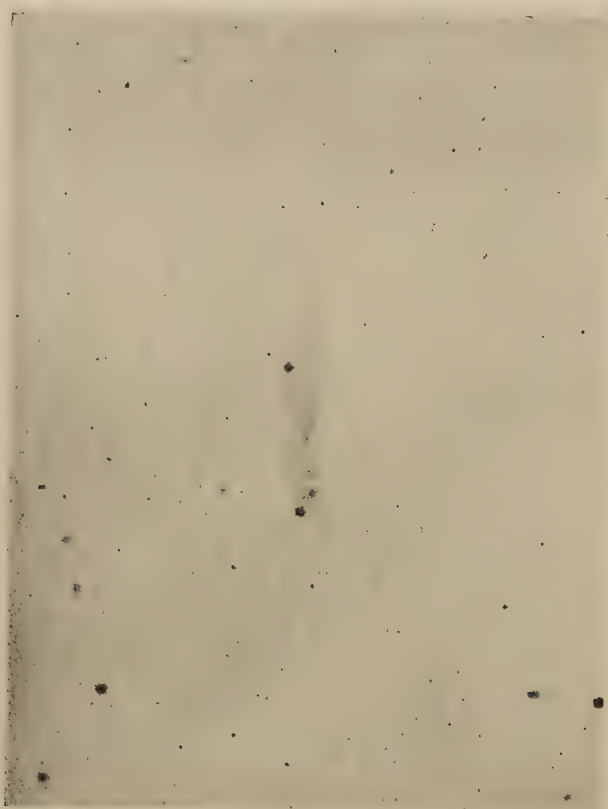


100 ×



150 ×

NGC 5496 in some different enlargements: Plate 6.



10×



20×



50×

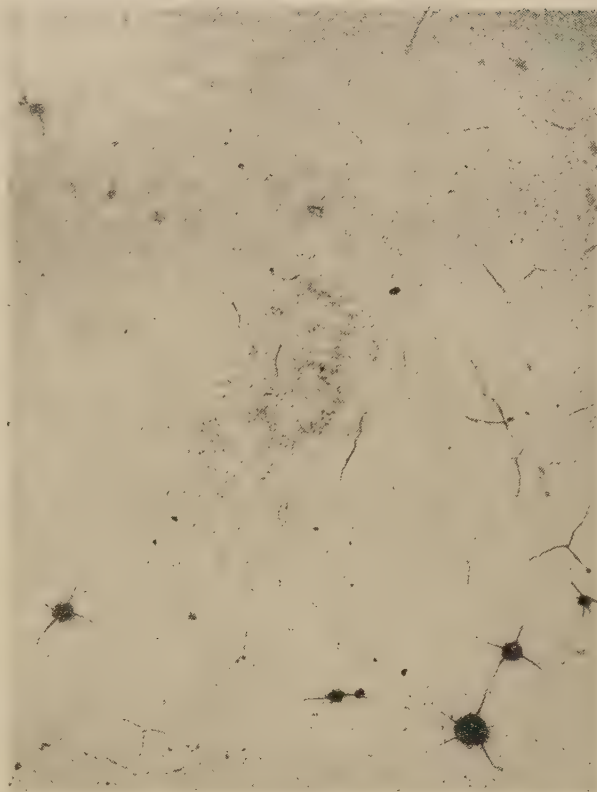


100×

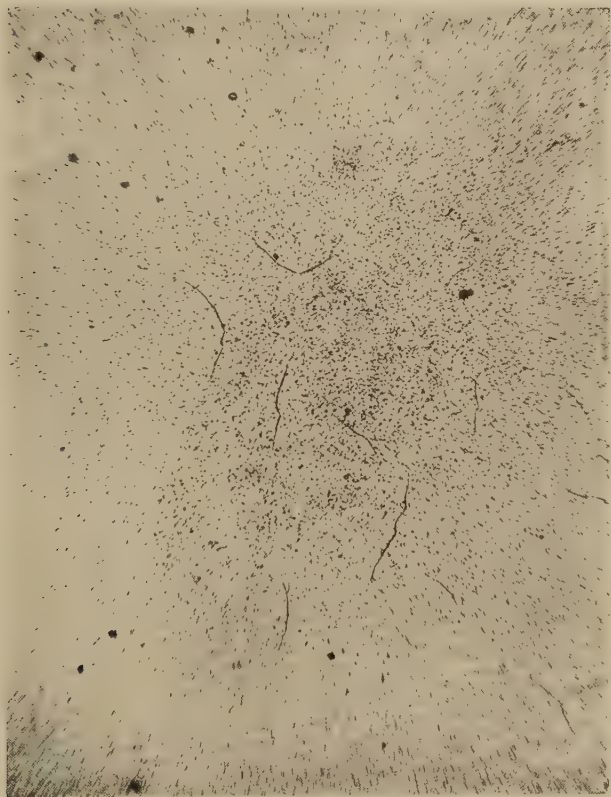
NGC 5861 in some different enlargements: Plate 7.



10×



20×

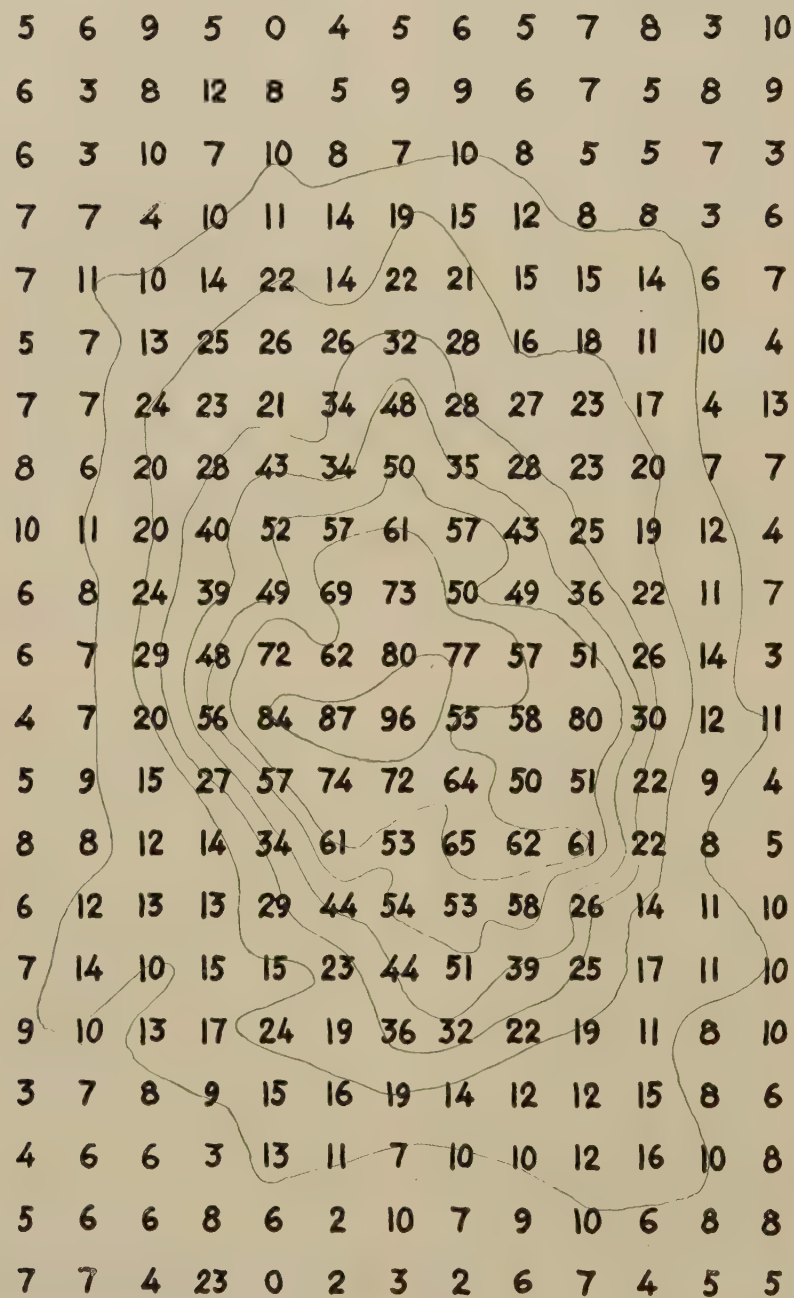


35×

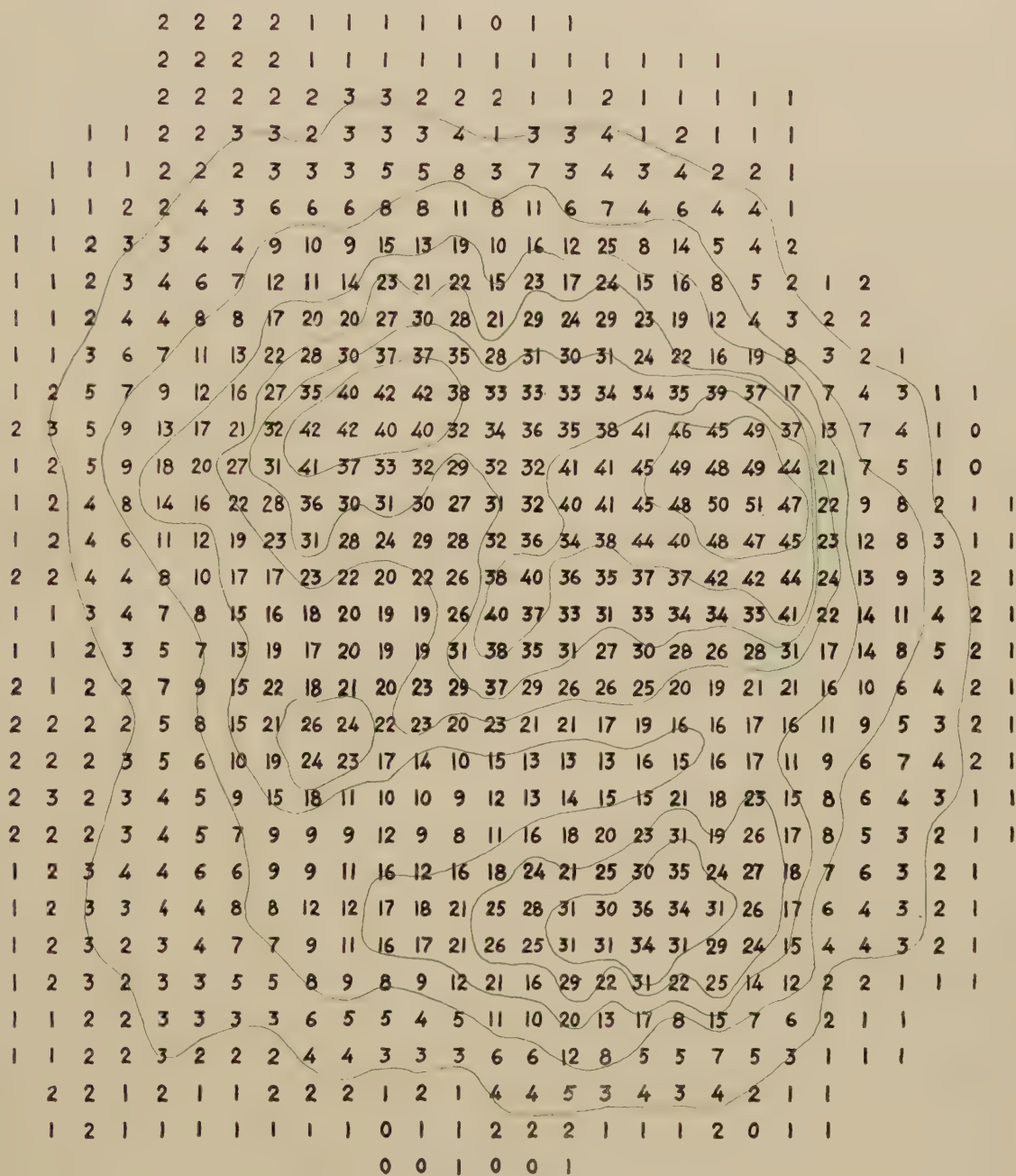


50×

Isophotal curves for NGC 337, obtained by measurements in a Schilt photometer: Plate 8.

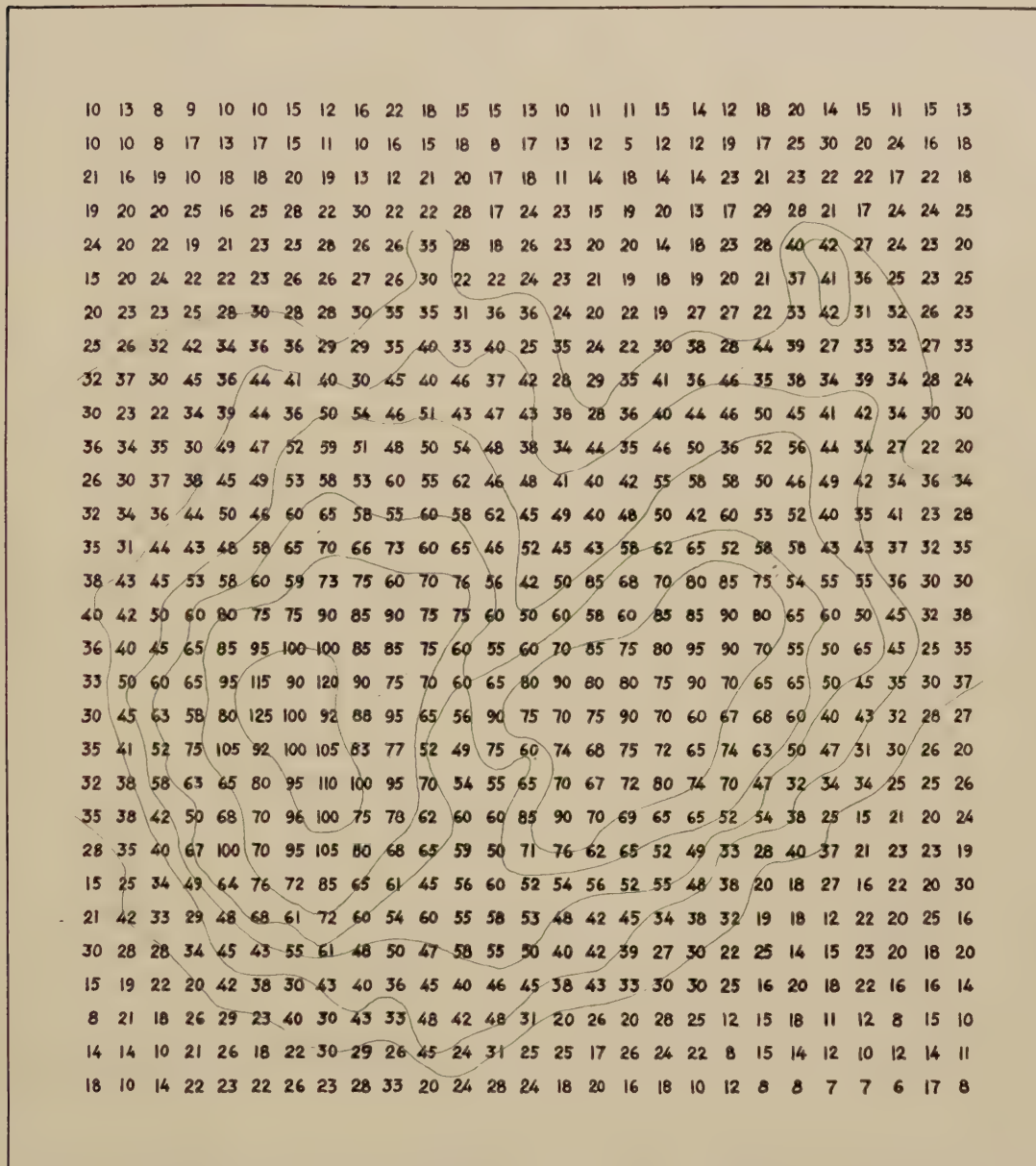


Isophotal curves for the nucleus of NGC 1097, obtained by measurements
in a Schilt photometer: Plate 9.

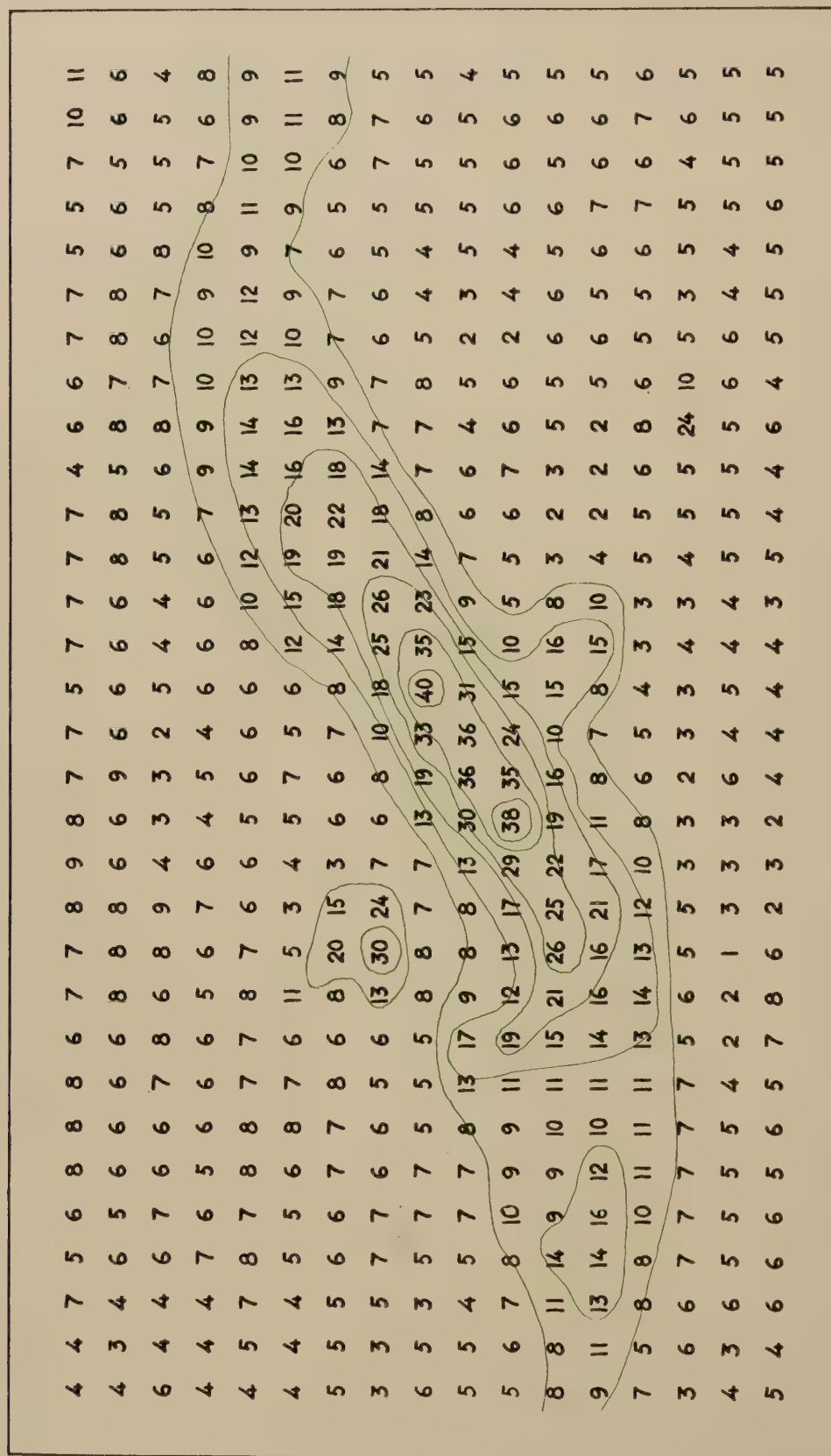


								8	3	6	2	3	2	1	2	7	8	9	6			
								6	8	5	8	5	3	2	3	3	8	10	9	7	6	7
		5	5	6	7	7	7	7	6	7	7	4	4	3	3	4	8	12	13	12	7	2
2	4	5	5	7	8	9	11	11	9	10	8	8	5	5	3	10	13	16	13	10	6	
3	5	8	9	8	8	9	11	13	11	12	12	8	6	5	4	10	14	17	12	9	5	
3	5	8	10	9	9	10	15	13	12	15	14	10	7	5	8	11	15	15	14	11	7	
4	8	9	9	11	13	12	17	16	15	18	17	15	11	6	12	14	16	16	16	10	6	
3	8	10	9	11	13	15	21	24	23	23	23	17	13	14	20	21	22	19	14	9	5	
5	9	12	14	15	15	15	23	29	29	31	25	22	19	22	26	27	25	18	14	8	3	
5	11	13	13	17	16	21	25	30	34	34	28	24	22	25	30	33	28	18	13	8	4	
6	13	14	14	17	17	24	29	37	38	34	28	24	26	33	41	35	27	19	17	8	2	
8	12	13	15	17	21	25	33	39	39	36	28	28	29	33	38	36	27	18	15	8	3	
9	11	14	12	14	22	32	45	46	41	35	29	32	37	36	38	29	23	15	9	7	2	
7	11	11	12	14	26	31	43	45	43	33	28	32	32	34	30	24	13	11	8	4		
7	8	10	10	12	22	29	39	45	44	35	27	30	30	30	28	22	12	9	5	3		
7	10	8	7	10	16	26	37	41	40	31	26	25	29	25	20	13	11	6				
6	9	9	8	9	14	20	30	34	33	26	23	25	25	20	16	10	14					
5	6	5	4	5	11	12	22	23	25	21	19	20	17	13	10	7	5	4				
5	6	5	5	4	6	7	11	16	18	17	17	17	13	12	8	6	4	3				
4	6	3	3	4	5	6	9	12	15	16	13	13	11	8	5	5	3	3				
3	4	5	3	4	5	7	8	9	14	14	13	12	10	7	6	5	4	4				
2	4	2	4	4	3	4	6	7	10	11	13	10	8	7	5	4	2	2				
3	4	4	4	2	3	3	26	12	8	8	8	8	5	4	3	4	1	3				

Isophotal curves for NGC 1365, obtained by counts of developed silver grains: Plate 11.



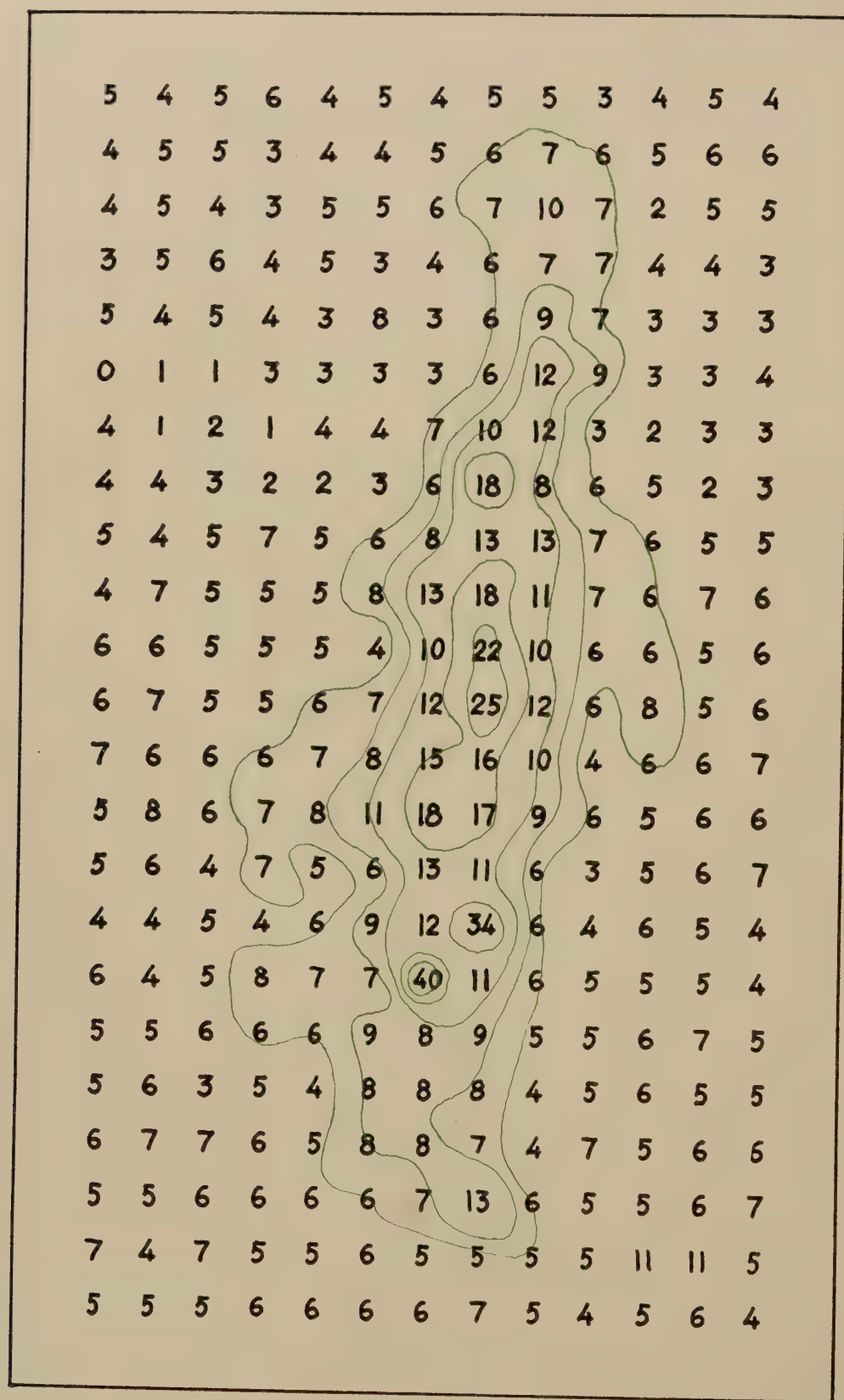
Isophotal curves for central part of NGC 4731, obtained by measurements
in a Schilt photometer: Plate 12.



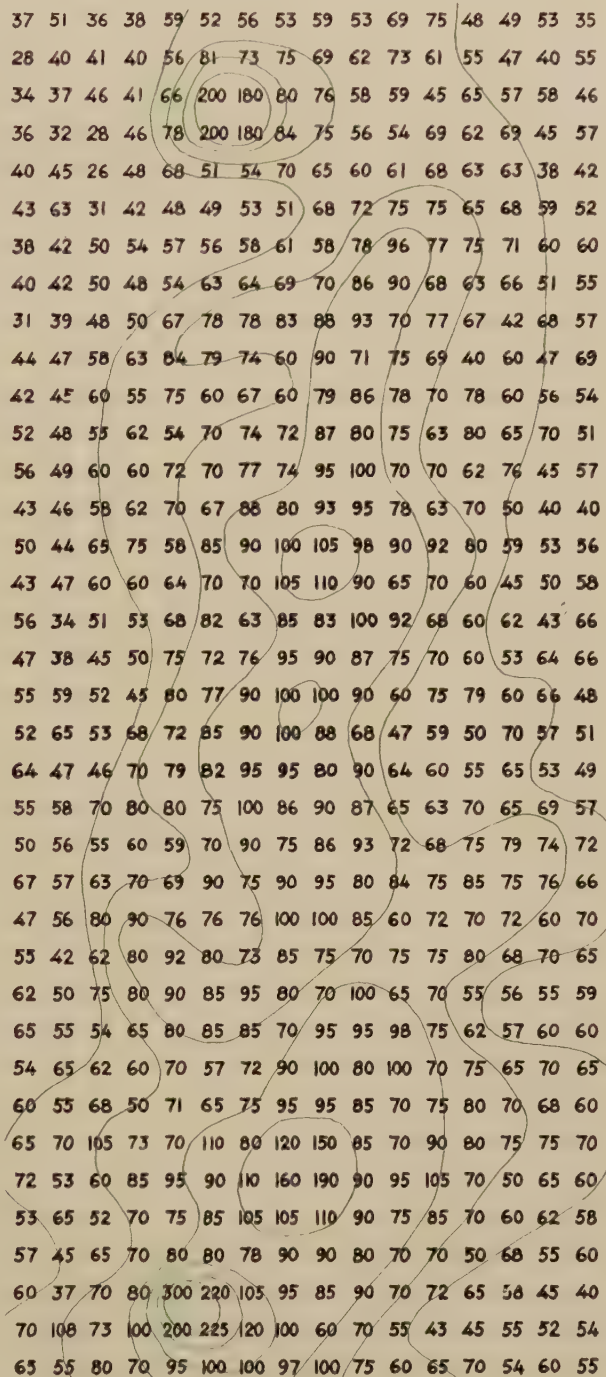
Isophotal curves for central part of NGC 4731, obtained by counts of developed silver grains: Plate 13.



Isophotal curves for NGC 5496, obtained by measurements in a Schilt
photometer: Plate 14.



Isophotal curves for NGC 5496, obtained by counts of developed
silver grains: Plate 15.



Isophotal curves for NGC 5861, obtained by counts of developed silver grains: Plate 16.

